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The Function of Light Railways.

No country more than our own has felt the need of a complete transportation system and none has more railways to show for it. Yet it is a fact that even in old and rather densely populated sections transportation is very unevenly developed, leaving large districts without adequate facilities. Railroads have grown over the country in a sprawling, irregular fashion ever since the zig-zag war dance of the Union Pacific over its land allotments. The result is that while the major transportation is fairly well taken care of, barring delays of six or eight months in side-tracked freight cars, the minor transportation that affects most intimately the life of the people as a whole has been in many cases badly neglected. Until the coming of the electric railway, rural communities had little chance for decent service, and even now they have not received the full benefits that are their due. Many interurban roads have been been built, it is true, but generally with an eye to important termini rather than to the intermediate country. There is a splendid service to be done by rural roads when the situation shapes itself so that they can be profitably built. The greatest present obstacle to this improvement is a certain species of megalomania among both promoters and the people to be served.

So far as the promoters are concerned they are naturally enough looking for profits. If they would confine themselves to operating profits all would be well, but the bankers who stand behind them are looking not so much for hard earned dividends as for a rake-off on the roads they underwrite. The practical question often asked is not how the proposed line can show the best earning capacity on the investment, but how large a bond issue it can stagger along under with due allowance for the probable growth of traffic. On the other side, it is hard for the enterprising citizens of Luggage City to realize that their town, population 2,311, is not to become in due season a metropolis second only to Chicago or St. Louis. Hence they view a franchise for an electric line through the main street as the source of indefinite future wealth, not to be granted without large concessions. When a railway proposition comes along through the country, it is hard hit by the local authorities, and having something of a swelled head itself, the total cost rapidly mounts to a figure that is entirely inappropriate save for a line between really important centers. Electric roads can be, but seldom are, built at cost low enough to secure adequate returns in sparsely settled communities, and until their cost can be kept down they will fail of their maximum usefulness. Now and then a light road is built with a proper appreciation of its legitimate functions, and it nearly always proves extremely valuable to its patrons and reasonably profitable to its promoters.

When a community is approached with a proposition for an electric road to bring it into communication with its neighbors, it may reasonably and properly ask good service and ordinarily favorable fares. It may also very properly insist that the capitalization on which the road must make its earnings out of the community shall represent a real investment in money or its equivalent, and that its projectors shall build and operate the road for legitimate transportation and not as a stock-jobbing proposition. If this is assured the community can very well afford to work hand in hand with the projectors and take its profit in increased business and valuation without demanding any considerable direct return from the franchise. In this way the community and the road are in a species of informal partnership that leads generally to good results. It has often happened that a well planned road has increased the value of property along its line to an extent that more than balances the cost of construction. This benefit is too often forgotten in striking a bargain for the future. A town gains far more in this way than does the railway, and, therefore, can afford to be generous. But the town should insist that the earnings to which it contributes shall be based on investment and not on water. To this end it should seek skilled advice on any propositions with which it has to deal and hold the project down to a conservative basis before it enters into any alliance whatever. If the promoters squeal when asked to squeeze out the water, they disclose their intentions at once and the more quickly they are thrown out the better. If they are willing to put their enterprise on a conservative and honest basis, the community will gain by helping the cause along in any proper way. Some of the best lines have been built with local aid in the taking of securities by enterprising citizens and when a proposed road starts in such wise it is pretty sure to give the community a square deal. But beware of the concern that places its bonds with a construction company and tries to unload its stock (very common stock) upon local investors.

The Clermont and the Lusitania.

It was on August 17, 1807, that Fulton's "Clermont" made her trial trip, at an average speed of about 5 miles an hour. She was 133 ft. long and measured 160 tons by the custom-house rules of that day. Her engine had a single vertical cylinder, which drove the side paddle-wheels through connecting rods and a bell-crank lever, and was rated at 19 h.-p. She was not the first steamboat, by any means, nor was she the first vessel propelled by steam to run in regular passenger service. Fitch drove a small boat by steam in 1786 and a larger one during the following year, the engine in each case actuating paddles on each side of the hull. In 1788 he built a third boat and 1790 a fourth, which was placed in passenger service between Philadelphia and Trenton for some months, probably being the first steam vessel to undertake such business. Rumsey built boats in this country and England about the same time as Fitch, and Patrick Miller also did the same in England. In 1802 the "Charlotte Dundas" made successful trips on a Scotch canal. Col. John Stevens' twin-screw boat of 1804 is almost as well known as the "Clermont," so it is evident that the achievement of Fulton has brought him enduring fame for some other reason than that of a strikingly original invention.

Almost one hundred years after the trial trip of the "Clermont" the new Cunard steamer "Lusitania" was given a series of trial runs that a good many marine engineers regard as equally significant to that on the Hudson a century before, in their influence on floating steam plant of high grade. This enormous ship, which will shortly start on her maiden voyage to the United States, is 785 ft. long over all and 760 ft. between perpendiculars. She has a molded breadth of 88 ft., a depth of 60⅓ ft. and a gross rating of 32,500 tons. She has accommodations for 552 first-class passengers, 460 second-class and 1,186 third-class. Her turbine engines have a nominal capacity of 68,000 h.-p. and she was designed for a speed of 25 knots. She is unique only in her great size, but this is not her important feature, which is the adoption of turbines under conditions far more severe than anything hitherto imposed on engine builders. The splendid showing made by this ship on her trial runs, when all contract requirements were exceeded beyond the expectation and even the wildest hopes of owners and builders, is a very significant indication of the fact that engineering will find some new tool or process to overcome difficulties that are insurmountable by anything available among past precedents. The "Lusitania" is very far from being the first turbine-driven ship, for many of them have been in service in the waters about Great Britain and some in the trans-Atlantic trade. But the problem presented to the designers of the "Lusitania" and her sister ship was not one of merely reaching forward from the safe footing of experience with these existing turbine vessels, but to make a bold jump for a distant goal, reaching which would be success, but failing which would be a disaster of the most serious kind. It is a tremendous advance from the 36,000 and 38,000 h.-p. rating, 23,600 and 26,000 tons displacement and 23½ knots maximum speed of the crack German liners to the 68,000 h.-p., 38,000 tons and 26.45 knots of the new Cunarder.

These two events in marine engineering gain their significance from their timeliness. Fulton was a great adapter and improver, as well as an inventor, and he was aided by Robert R. Livingston, whose business ability supplied the incentive for the "Clermont." The latter foresaw what steam propulsion would mean if commercially successful, and in 1798 he had secured from the New York legislature an exclusive franchise for the navigation of the Hudson by steamboats. It was the existence of this franchise which compelled Col. Stevens to abandon his project to establish steamboats on the river, for which service he completed, almost as soon as the "Clermont," the "Phœnix," which is credited with having made the first deep-sea voyage under steam in her trip from Hoboken to Philadelphia in 1809. Fulton and Livingston together were masters of the art of utilizing and improving existing apparatus and finding a commercial purpose for it, and were thus real captains of industry, in the modern sense. In the same way, it may be said that the owners and builders of the "Lusitania," with their technical staffs, have accomplished a great beneficial work. Just as Fulton and Livingston showed that commerce need not be fettered by the caprice of the winds but could utilize to its advantage the steam engines which had already thoroughly established themselves on land and made some attempt to win recognition afloat, so the British shipmasters and shipbuilders have proved that commerce need not be fettered by the limitations of the reciprocating engine, but will find in the steam turbine a means of driving ships as large as harbor channels will admit and as fast as passengers will pay to be carried. The beautiful ship recently turned out from the Clydebank yards may therefore be considered to open another century of marine engineering with a promise of achievements that cannot even be sensed now.

Grade Crossing Elimination in New Jersey.

The crossings of railways and highways at grade in New Jersey have a number of features that make their elimination a matter of more than usual difficulty. There are many of them in the State, as might be expected from the great railway mileage per 100 square miles and the early date at which a large part of the lines were constructed. These death traps are now numerous in districts which had only a few country roads when the railways were built, and, in many cases, the crossings have been put in at grade against the vigorous protest of the companies. Their danger was appreciated by the railway officials, but the county and town authorities failed to foresee it, and consequently there has developed a sort of disregard, as something inevitable, of fatalities and injuries due to the collision of trains with vehicles. Recently there has been some local half-hearted opposition manifested in a few places to a continuation of these serious conditions, but no real study of them has as yet been undertaken except by the railways themselves. The latter have already carried out some extensive works at a heavy expense, the most recent undertaking being the elimination of grade crossings on a large part of the Morris & Essex division of the Lackawanna R. R. This elimination work has only been begun, however, for in the places where grade crossings are most dangerous it is extremely difficult and expensive. In these districts there is an enormously heavy train movement at certain hours of the day, when people are traveling between New York, Jersey City, Hoboken and Newark and their suburban homes. Any interference with this passenger traffic affects a large number of people, many of them men of large affairs whose time is extremely valuable. It is also necessary to keep streets open in some way at many of the worst crossings, for otherwise serious inconvenience would result to important business interests.

A new State Railroad Commission has recently been appointed, which has shown indications of a desire to take up the problem of eliminating grade crossings, along with other features of railway affairs. It is a matter of considerable doubt just what powers this body posessses, for it was created by the legislature in a hastily drawn and manifestly crude act. In some respects, it is apparently merely an advisory commission, but it seems to have definite authority to order railway companies to make such reasonable changes in their roadbeds, tunnels and bridges as it considers in the interest of safety. Whether it can compel the companies to execute such orders remains to be seen, and it is open to question whether the elmination of grade crossings can be legally included under such a classification as that mentioned, for grade crossing accidents rarely hurt the train crews and passengers whose safety is supposed to be the purpose of this provision in the legislative act. It will be a good thing, however, for the commission to ascertain by test cases as soon as practicable just what powers it has, for until it has done so its work will be of problematical value. It seems certain that some State commission should have liberal powers in connection with grade crossing betterments, in order that the problem may be thoroughly investigated as a whole and the work may be directed in the interests of the people of the whole State rather than those of a single city or borough. It is often impracticable to alter grades materially in one city without introducing conditions that make changes necessary elsewhere, for otherwise a succession of short ascents and descents will disfigure the profile of the track. As conditions are now, one community can make so much trouble that improvements affecting the safety of travel in an entire district are held up indefinitely. The law should be so drawn that the commission will have power to authorize a railway company to go ahead with an important improvement under such conditions, leaving the settlement of the disputed matters to arbitrators whose decision shall be final.

For some reason that it is hardly worth while to attempt to discover, there is an apparent prejudice against any division of the expense of grade-crossing elimination between the railway companies and State and local treasuries. Whether this feeling really is a general one, or is held only by that portion of the community which supports the local newspapers expressing it and is not shared by the much more influential suburban population of the Northeastern part of the State, is open to doubt. It seems to be the prevalent opinion, however, and it ought to be generally made known that until this opinion is materially altered the progress of grade-crossing elimination will be distressingly slow. There is nothing equitable about forcing all the expense of eliminating these crossings upon the railways, for in many cases they have been made by local public authorities against the desire of the companies, and in other cases they are the result of the development of a town which has been made possible only by the service given by the railways. In Massachusetts, where more work of this nature has been done than elsewhere, only 65 per cent. of its cost is charged to the railways; New York and Ohio charge 50 per cent. to the companies, and Connecticut and Rhode Island have also made provision for a distribution of a part of the expense among public bodies. There is the more reason for hoping that the equitable practice of other States may soon be introduced in New Jersey for the reason that before long the electrical operation of surburban trains into the terminals on the Jersey side of the North River will become necessary in order to handle the greatly increasing passenger traffic, and the adoption of electrical operation must wait upon the elimination of grade crossings. It would be far better for the traveling public, which forms by far the most important part of the population of Northeastern New Jersey, to bring about something like the Massachusetts system of apportioning the expense of grade-crossing elimination than to continue to obstruct railway work, which is directly in its own interests, by fostering a sentiment not based on justice and equity, but dug up from the wording of old charters granted in the days when a mail coach could give a railway train a good stiff race. The problem is one of present necessities and not a subject for library research into ancient legislation and the opportunities for legal hair-splitting.

Rejecting Low Bids.

It is quite a common impression that in competitive bidding for municipal contracts the award should be made to the lowest bidder, or at least that it should be so made unless there is glaring lack of responsibility. There are, however, many cases in which the statute governing awards not only does not require the contract to go to the lowest bidder, but distinctly charges the awarding power to select such a responsible bidder as will execute the contract to the greatest advantage of the municipality. The City of New York is a marked instance of this kind. Two of its boards at least, one the Aqueduct Commission and the other the Board of Water Supply, act under statutes giving them a wide latitude in the award of their contracts, but laying upon both those bodies a far heavier obligation and a duty of far graver responsibility than if they were rigidly bound to award their contracts to the lowest bidders. As the matter stands, both the Aqueduct Commission and the Board of Water Supply must consider seriously whether they are properly discharging their duties in awarding any competitive contract to the lowest bidder. In other words they must scrutinize most thoroughly and carefully every feature of tenders made to them for constructing the public works under their charge, and determine, in view of all the considerations involved, which offer they will accept. The laws governing their action do not even direct them to make the award to the lowest responsible bidder. It is difficult to conceive of graver responsibilities placed upon public officials in rendering such a kind of service. A political commissioner might consider these conditions admirably adapted to serve his puprose in favoring his friends, but a conscientious officer will realize that his action under such circumstances must be guided by the most scrupulous regard for the public trust imposed upon him.

Some rather unusual experiences in connection with the contracts under the Aqueduct Commission and Board of Water Supply have lately been observed. It will be remembered that the former body awarded the contract for the Cross River dam to the highest bidder but one, out of five, while the contract for the Croton Falls Dam went to the bidder next higher than the lowest, both awards being in accordance with the recommendations of the chief engineer. The first of these instances was so unusual as to receive approving editorial comment in this journal. The wisdom of the recommendations of the engineering organizations of both the Aqueduct Commission and the Finance Department of the City of New York has been shown by the present practical completion of the Cross River dam within the prescribed contract time, in spite of serious legal delays for which the contractor was in no way responsible. This is probably the first instance of the completion on contract time of any great public work in the history of the City of New York, or at any rate for so long a period that "the memory of man runneth not to the contrary."

The result of the bidding for the main dams of the Ashokan reservoir apparently placed the Board of Water Supply in much the same condition which confronted the Aqueduct Commission when the tenders for the Cross River dam were opened, with the additional complication of an amount of public money several times larger being involved. As has already been announced in The Engineering Record there were five responsible bidders for this work, the tenders varying from a little above ten millions to a little below fifteen millions, the extreme difference being nearly fifty per cent. of the smaller sum. The Engineer's estimate of the cost of this work is reported to be about two and a half millions above the lowest bid. In other words the latter was probably somewhat under the actual cost of the work, assuming that all the exigencies inevitably developing in connection with such operations are reasonably favorable. When it is remembered that such exigencies are on the whole practically certain to be unfavorable, there is the same practical certainty of a material loss resulting to the contractor who should attempt to execute the contract at the lowest bid. The next highest bid was about $2,300,000 above the lowest. The serious question arose whether the Board of Water Supply should award this large contract at a price below cost, even to parties entirely responsible.

In the first place, as is well known, it is not only desirable but absolutely imperative to bring the Catskill water to the City of New York in the shortest possible time. No person experienced in the execution of contracts for the public works of this city can suppose for a moment that that imperative condition would even be approximately fulfilled by any contractor losing money in doing it. No matter how responsible he may be the work would lag and lag seriously when its prosecution incurs a loss. Further than this, experience has shown with equal certainty that a losing contractor will use every means within his power to recoup such losses. Every contract furnishes opportunities for such efforts, and the larger the contract and the more powerful the contractor, the more those efforts will be made, and the greater will be the success attending them. The final results, therefore, would be a greatly delayed completion of the work with costs so greatly increased over the contract price as easily to overcome the difference between the original bid and that next above it. At the present time heavy judgments against the city have been secured by contractors under precisely the conditions outlined above and this case would certainly be added to those by any contractor doing the Ashokan work at a loss.

The statute governing the Board of Water Supply is absolutely clear in requiring its members to act in the best interests of the city largely independently of the prices bid, and there are already exact and weighty precedents for their guidance. The Board of Water Supply could not have rendered a better service to the city or more wisely have discharged its resopnsibilities than by awarding the contract for the Ashokan dams to responsible contractors of experience in this line of work, as reported in this issue of The Engineering Record at a price which, with good management, will yield a fair profit, even at an apparent sacrifice of $2,300,000 by rejecting the lowest bid.

Notes and Comments.

The Use of Streets by interurban electric cars in Indianapolis was recently considered by the Indiana Supreme Court in Kinsey v. Union Traction Co. The decision was one of the most voluminous ever handed down by that court, but its most interesting feature to city engineers is summed up as follows in 81 N. E. Rep., 922: "A street railway company operating on a city street, for the carriage of freight and passengers, interurban trains of three cars, each 60 ft. in length, at a rate of 20 to 30 miles an hour, thereby rendering the use of the street dangerous and causing the house of an abutting owner 60 ft. from the track to shake so as to cause the plastering and ceilings and the pictures on the walls to fall, and to disturb the comfort of the owner and his family occupying the house, is liable to the abutting owner for the special damages sustained, the operation of its cars in such a manner by a street railway being unlawful and unjustifiable."

The Chicago & Alton change of ownership has been inevitable for some time, although just who would take the property has been in doubt. Its ownership by the Rock Island has been possible just so long as the Government refused to let it come within the scope of its official knowledge, for the Rock Island and the Alton are competing lines and one could not acquire the other without running into legal complications and dangers that are not gratifying to the stockholders The line has been purchased by the Toledo, St. Louis & Western R. R., better known as the Clover Leaf road, and the companies associated with it under the control of Mr. Edwin Hawley, namely, the Minneapolis & St. Louis R. R. and the Iowa Central R. R. With the Alton, a system is thus formed with something over 3,000 miles in the best part of the Central States, reaching over its own lines into Chicago, St. Louis, Kansas City, Minneapolis, Des Moines, Toledo and Detroit. It is a system that can be developed into a very strong competitor for business between Chicago and Kansas City and western points, while its local business in some sections will always remain large. The purchase is not yet definitely closed, for the Hawley interests do not care to buy a law suit, such as is possible until the Government definitely determines whether it will take action against the Alton in connection with the rebates which resulted in the $29,000,000 fine imposed on the Standard Oil Co. It will undoubtedly be a good thing for shippers and travelers to have the deal carried out, for it is much easier to do business with a large system capably managed than with a number of short independent lines.

Professional Ethics are now receiving the attention of the American Bar Association, in some respects the most influential professional organization in the country, and it is reasonable to expect important results from its deliberations. At present there are codes in force in Alabama, Colorado, Georgia, Kentucky, Maryland, Michigan, Missouri, North Carolina, West Virginia, Wisconsin and Virginia. Eight canons of professional conduct are incorporated in the charter of the Louisiana Bar Association and the oath administered to lawyers admitted to the bar in the State of Washington contains a brief outline of professional duty. A committee representing all sections of the country has been investigating the subject and at the meeting of the American Bar Association on Tuesday of this week, it presented a rough draft of a proposed code in order that all interested in the subject may have an opportunity of sending their views to the committee. The adoption of such a code is deemed to presage such important effects on the development of the legal profession that the committee believes it should be done only after mature and careful deliberation, and much fuller consideration than can be given it at an annual meeting. This wise recommendation and cautious procedure is recommended to those who are interested in the subject of professional ethics among engineers, a class which must eventually come to some code, although there does not seem at present to be any early prospect of the adoption of such canons. If those who feel the need of a code were to act with the deliberation and the regard for all criticism which mark the work of the American Bar Association's committee, there would probably be a better chance of securing an engineering code that would be of real use as a stimulus to higher professional conduct.

The London Water-Works, which have been under public ownership for about three years, now supply a population of about 6,800,000. Part of the people living outside the administrative County of London doubtless obtain water from private wells or other sources, for the average daily consumption of the public supply is only 261,600,000 gal., or 38 gal. per capita. About one-quarter of the supply is ground water and the remainder is from the Lea and Thames. As a result of centralized public ownership, the various districts formerly served by independent companies have been coupled together, so that any extraordinary conditions in one district can be met by drawing on the resources of others. As a result of these new connections there has been a great increase in the quantity of water taken from the Thames for two districts. These results have led to hearty approval of the management of the works by those usually opposing municipal ownership.

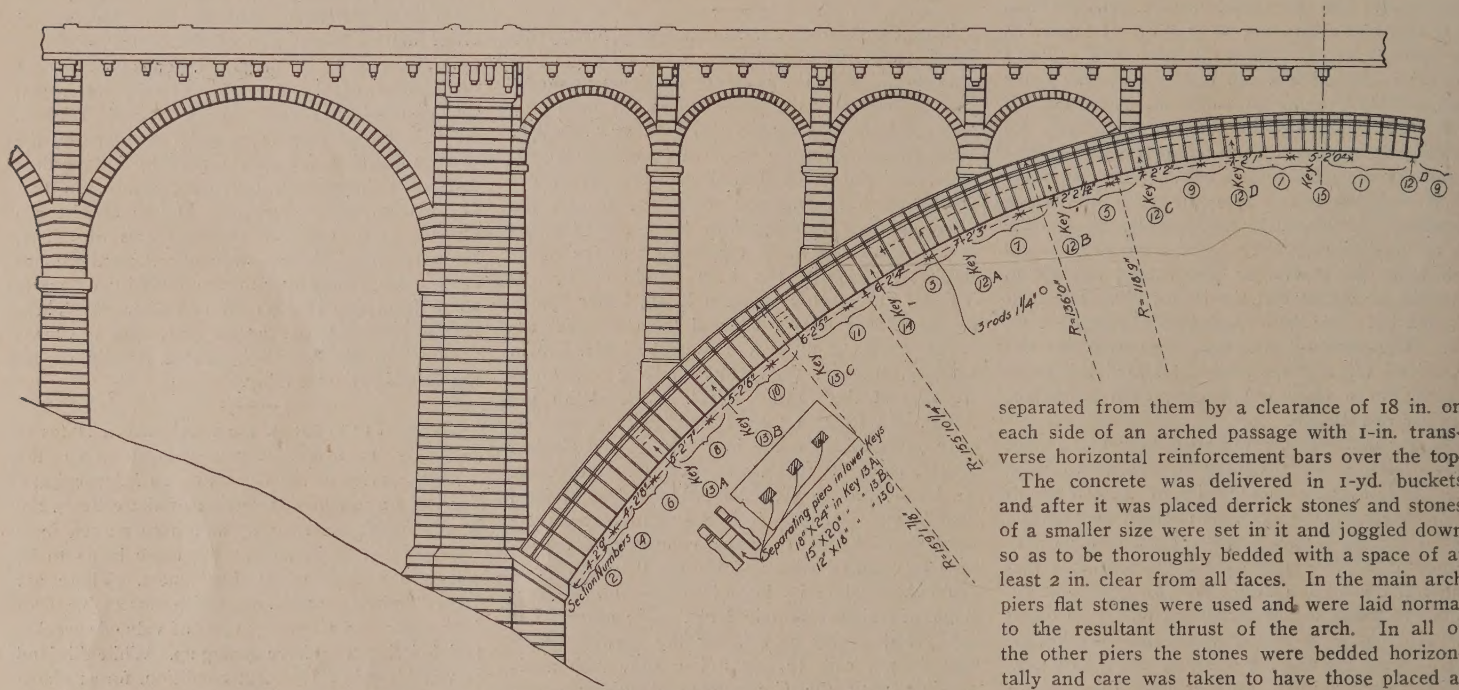
Forest Planting in the northeastern states is receiving particular encouragement from the Forest Service of the Department of Agriculture, for large areas in this section of the country are fit for forest growth only and from an economic standpoint it is important for these lands to be put into a state of productiveness. There are large lumbered areas on which successive fires have destroyed all young trees of valuable species, and inferior trees have sprung up. While this land is worthless in its present condition, forest planting will bring it into a useful state where adequate protection against fire can be provided. There are also large tracts, once cleared for farming, but since abandoned on account of loss of fertility or through the greater attractiveness of cities to their owners. In places these abandoned farms are now covered with white pine, but this crop is being removed rapidly and little reproduction will follow, owing to the absence of seed trees. Such lands offer exceptionally fine opportunities for forest work, owing to their nearness to markets and freedom from brush. There are also large barren sand plains in the New England states and New Jersey which cannot be cultivated, but will support in many cases a fair growth of white pine or other species of pine. The high price of good timber, which is sure to steadily increase, coupled with the presence of these lands near good markets, should be an incentive to take forestry up earnestly. It will accordingly be strange if far-sighted men with enough capital to undertake the work do not take advantage of the opportunities afforded in the northeastern states to make an investment which is likely to bring in a good revenue and also furnish an opportunity of supervising about the most interesting outdoor work that can be undertaken. From a purely engineering point of view, it is to be hoped that the suggestions of the Forest Service will be put into immediate practice, in order that the local timber supply may be increased instead of considerably depleted.

THE WALNUT LANE BRIDGE, FAIRMOUNT PARK, PHILADELPHIA

A Description of the Methods Employed in Constructing a Concrete Arch of 233 Feet Span.

The highway bridge carrying Walnut Lane over Wissahickon Creek in Fairmount Park, Philadelphia, is a concrete structure 585 ft. long, 60 ft. wide and about 150 ft. in height above the surface of the water. The main span, 233 ft. long in the clear, has a rise of 70 ft. 3 in., and is flanked by five full-centered approach spans of 53 ft. The main span is the longest concrete arch in the world and the third longest masonry arch of any description; its general features were illustrated in The Engineering Record of November 17, 1906.

It is made with two ribs, each 18 ft. wide and 18 ft. in the clear from the bridge axis. The radial thickness of the ribs diminishes from 9½ ft. at the skew-back to 5½ ft. at the crown and each is made with 22 long voussoirs and 17 short ones, the latter serving as keys, and all of them being cast in forms built on the regular arch lagging. The vertical faces of the voussoirs are scored 1¼ in. deep in radial lines from 24 in. apart at the crown to 33 in. apart at the skew-back to give them the appearance of cut stone course joints and the outer faces are grooved with a curved concave moulding of 5 in. radius, parallel to the soffit, above which the vertical face projects 2½ in. farther than it does below it.



Walnut Lane Bridge Showing Voussoir Scoring.

Ten vertical transverse walls built up from the arch ribs to the level of the crown carry at their upper ends the 20-ft. longitudinal spandrel arches, the cornice and parapet and four lines of longitudinal spandrel walls supporting the roadway platform. Transverse I-beams 6 ft. apart are seated on the longitudinal wall spanning each rib and the space between the ribs, and carry the transverse floor arches 9 in. thick at the crown above which there is a cinder concrete filling and asphalt roadway. The arch ribs are made without reinforcement except for three 1-in. horizontal transverse rods at the foot of each transverse spandrel wall and six 1-in. rods bent at right angles to bond the horizontal seat for each transverse wall with the rib. The transverse spandrel walls are reinforced with 1-in. horizontal rods 3 ft. apart vertically.

The skew-backs of the main span and the vertical piers at the same point are both seated on a common foundation 58 ft. 2 in. long and 29 ft. wide, with its footing carried down to offset seats in the solid rock a few feet below the sloping surface of the ground.

The approach arches and their piers are of ordinary simple construction, and, like the main arch, are made with two separate ribs joined by the continuous roadway platform. The abutments are of solid concrete masonry with heavy cross sections to act as retaining walls for the embankment behind them, their faces are paneled to give the effect of piers for the ends of the approach arches above which recesses are formed to receive the spandrel walls. The wing walls are curved, the faces are vertical and the rear is offset to the required thickness, making, altogether a somewhat elaborate construction of large dimensions, their height being over 50 ft., and the length more than 100 ft. transverse to the axis of the bridge. The wings and the faces are reinforced with 1-in. horizontal rods 2 ft. apart vertically, curved around the corners.

The floor platform is uniform over the main and side arches, and the 20-in. transverse I-beams which support it between the arch ribs are spliced to the 15-in. beams which support it over the arch rib by horizontal angles bolted to the webs and flanges of the beams, as shown in the detail. The lower flanges of the I-beams are protected with 3-in. of concrete reinforced by loops of 3-16-in. wires, 3 in. apart, spaced by 2 pairs of horizontal transverse ⅛-in. wires. The floor slabs have transverse expansion joints on the center lines of all the transverse spandrel walls.

The bridge is proportioned throughout for a live load consisting of 100 lb. per square foot or a concentrated load of forty tons on two axles 20 ft. apart, the wheels 6 ft. apart on the axles, and for a wind pressure of 50 lb. per square foot of vertical surface. The dead load of the center span is about 26,000 tons, nearly one-half of which is due to the weight of the arch ring alone. The maximum unit stress in compression on extreme fibres of the arch at the points of greatest eccentricity of the center of pressure is 500 lbs. per square inch, which includes temperature stress, and the maximum total stress at each skew-back is 16,500 tons.

The vertical shear at the skew-back gives a unit stress greater than is allowable on plain concrete, and a much higher value in shear is obtained by embedding in the concrete radial one-man stones. The form of the arch curve was determined by and follows closely the curve of the line of pressure, which is contained well within the middle third of the arch ring.

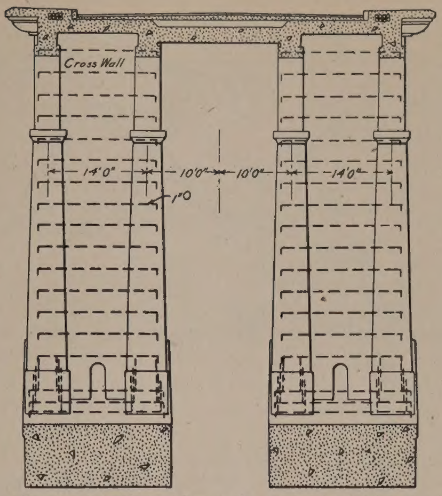
The footings of all piers and abutments were carried down in open excavation to solid rock, which in all cases was dry and developed ideally rugged surfaces in sound hard material from about 5 to 20 ft. below the original surface of the ground. The foundation pits were excavated by hand and only in a few cases required any sheeting. The footings were built with 1:3:6 concrete and were made solid to a level above the surface of the ground where for each pier they receive two shafts carrying the separate arch ribs. A 30-in. water main just above the surface of the rock passes through all of the foundations in a line parallel to the axis of the bridge and is separated from them by a clearance of 18 in. on each side of an arched passage with 1-in. transverse horizontal reinforcement bars over the top.

The concrete was delivered in 1-yd. buckets and after it was placed derrick stones and stones of a smaller size were set in it and joggled down so as to be thoroughly bedded with a space of at least 2 in. clear from all faces. In the main arch piers flat stones were used and were laid normal to the resultant thrust of the arch. In all of the other piers the stones were bedded horizontally and care was taken to have those placed at the end of each day's work project about half of their height above the surface of the concrete so as to form dowels bonding the concrete with that to be laid the next day.

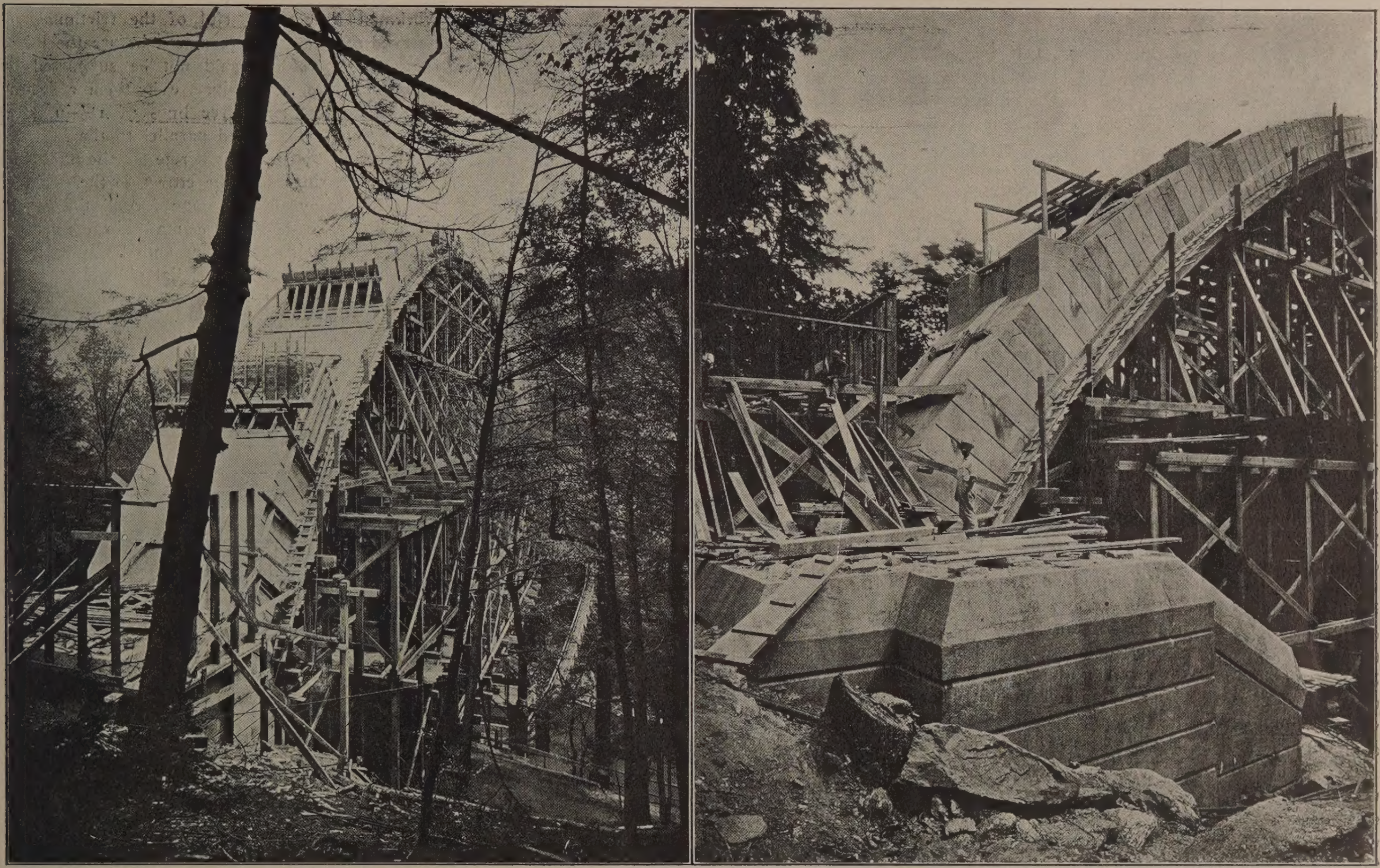
Above the surface of the ground the piers were built in ordinary forms made with 2-in. horizontal boards 18 in. wide, planed on the inner face and on the edges and secured as usual by vertical outside studs with tie rods through the upper ends. The lower ends were secured by ¾-in. bolts 12 in. long with their inner ends engaging nuts and washers permanently embedded in the pier concrete 8 in. back from the face.

Courses of concrete four boards deep were laid daily and the bolts securing the lower four boards of the forms were unscrewed from their nuts and taken out and the boards removed and built on top and the holes left in the concrete were filled with plaster. Triangular horizontal strips 2½ in. wide and 20½ in. apart vertically were attached to the inner faces of the forms to produce course joints in the face of the concrete. On the day after the concrete was placed the form boards were removed and the surface was scrubbed with a brush and rinsed with water, which produced a very uniform color and texture and entirely removed all traces of the form boards.

The centering for each of the 53-ft. arch ribs was made with seven triangular wooden trusses 4 ft. apart on centers which spanned the full width of the arch and were carried at the springing line on transverse horizontal 10x10-in. yellow pine upper sills, supported by pairs of oak wedges under each truss on 10x10-in. lower sills scabbed to vertical 10x10-in. posts set on the rock bottom adjacent to the mould for the pier foundation. The trusses were like scissors rafters with straight lower chords made of two spliced 3x12-in. planks with zig-zag bracing to the top chords which consisted of ordinary scarf boards made with two 3x12-in. planks bolted together. Forms were built on the lagging and loaded with stone at the crown and the arch rings were built up from both skew-backs simultaneously to the crown, care being taken to finish the work each night on radial planes parallel to the axis of the arch. The false-work and forms for each of the 53-ft. spans was built by a party of seven men in about four days and the 140 cu. yd. of concrete in the arch ring were laid in one day. When the concrete was one month old, the centers were struck by carefully slacking the wedges and no settlement at the crown could be perceived. No especial delay was required before commencing the 53-ft. spans after the completion of their piers. It was, however, required that the main piers should be completed at least 30 days before commencing the concreting of the main arch rib.



Cross Section through Spandrel Arch.

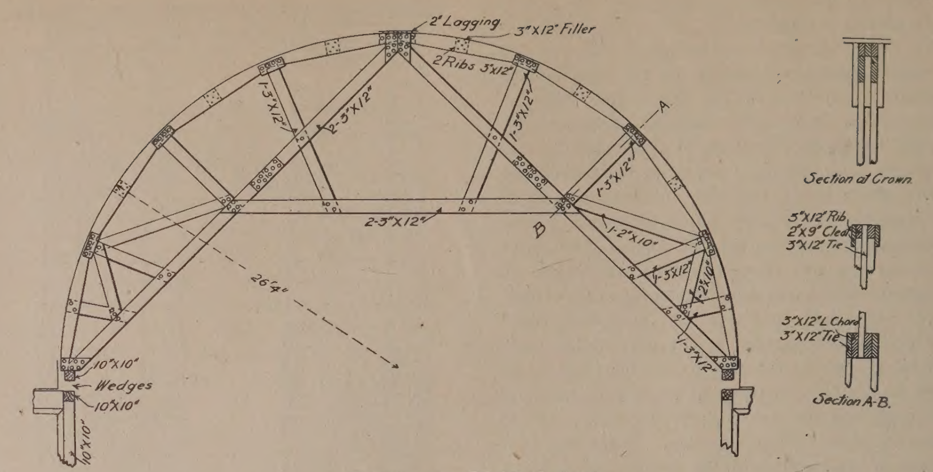

Construction of First Rib of Main Arch, Walnut Lane Bridge.

Each main arch rib with its transverse spandrel walls contains about 2,400 cu. yd. of concrete and imposes a maximum load of about 6,000 tons on the false-work. The application of this great load varies with the changing condition of the concrete as it gradually drys and sets and develops different frictional resistances on the lagging. To provide for the somewhat indeterminate stresses and prevent deflection the false-work was made heavy. The upper part of the false-work was trestled separately from the lower part and divided from the latter by a space for the adjusting wedges. From this line down to a level considerably below the skew-backs, where it was supported on a steel and masonry sub-structure, the false-work was braced to form a lower section.

The sub-structure is carried on concrete piers about 85 ft. long and 2 ft. wide on top. All of them have their footings carried down to solid rock and have their faces battered 1:12. On shore the rock is near the surface of the ground and the heights of the piers vary from 2 to 8 ft. The four piers in the creek are about 12 ft. high and were built in cofferdams made with cribs sheeted inside and filled with puddle. Each of the creek piers carries a transverse steel bent 50 ft. long and 20 ft. high, made with ten 12-in. 31½-lb. vertical I-beam posts bolted to top and bottom pairs of horizontal 12-in. 25-lb. channels forming caps and sills, between which they were X-braced with two sets of 6x3½-in. angles. The caps carry ten lines of 24-in. 80-lb. longitudinal I-beams, the five panels of which have a total length of 132 ft., and are supported at their extremities on the shore piers. The false-work proper is 232 ft. long and 42 ft. high and has twenty-one transverse bents. Except at the ends the bents are all two stories high and all are made with ten vertical posts and two panels of 2x9-in. X-bracing in each story.

The upper section of false-work 30 ft. wide has its 15 transverse bents in the same planes as the center bents of the lower section of false-work and each bent is made with six vertical posts in one, two, or three stories, each with a single panel of X-bracing. The ends of the first story caps are braced by batter posts to the ends of the first story sills, thus giving an extended base for lateral stability. False-work is braced longitudinally by six lines of double panel X-bracing and horizontal ledgers in the upper section of the false-work and eight sets in the lower section.

All X-braces are 2x9-in. planks, the upper and lower ledger pieces of each section are 4x12-in. and the intermediate ones are 3x12 in., and all other timber in the false-work is 10x10-in. yellow pine, except the 10x16-in. caps of the upper story which carry 6x16-in. and 6x18-in. scarf timbers spaced 12 in. apart on centers and covered by 1½-in. tongue and groove lagging 28 ft. long, planed on the upper side. The falsework contains about 370,000 ft. b. m. of timber. Fire protection is provided by a 1½-in. water main under 75 lb. city pressure, which extends from end to end of the bridge and is provided every 50 ft. with a tee having its outlet closed by a screwed nipple with the outer ends flattened and welded. These nipples were removed and streams were played on the false-work, soaking it thoroughly for 48 hr. before the keys were concreted between the arch voussoirs. At this time the weather was hot and during the succeeding five weeks the timber dried out so much as to cause considerable shrinkage but not enough to release the false-work from the concrete arch. It is considered, however, that the shrinkage afforded a very slow and delicate diminution of the pressure and was very desirable

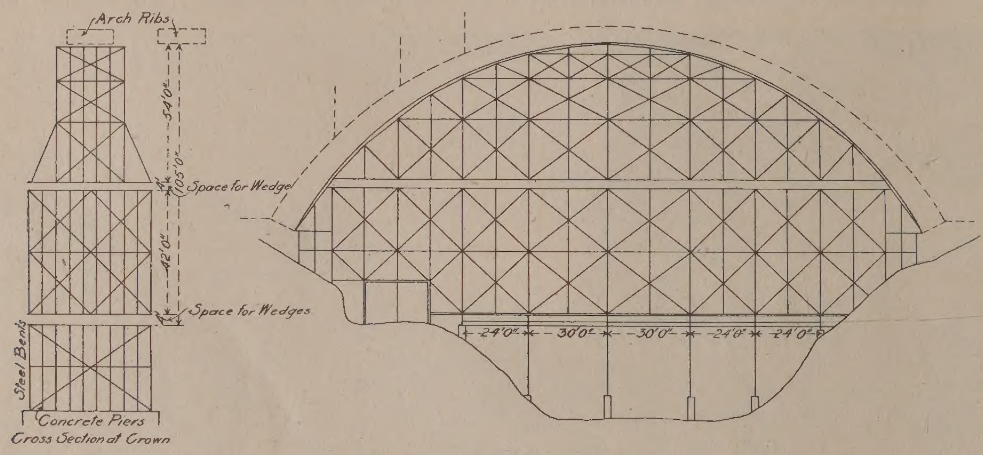


Center for 53-Foot Arch.

in transferring the stresses from the falsework to the arch ring.

The steel sub-structure, and the end main bents of the lower part of the timber false-work, take bearing on fifty 6-in. steel rollers 18 in. long, parallel to the axis of the bridge which are engaged on top of the concrete piers between continuous 19 × ¾-in. top and bottom back plates. While construction work is in progress all bents are anchor bolted to the piers and the rollers are immovable.

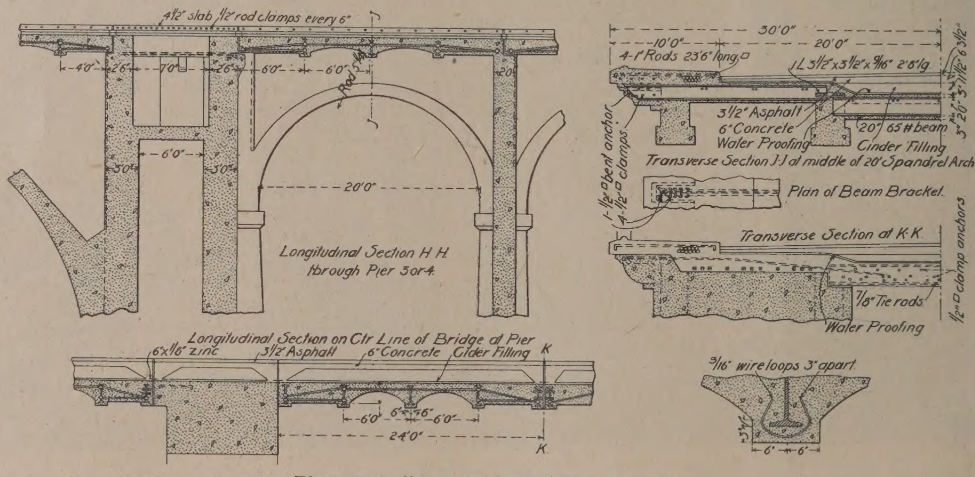
A ladder and a wooden hand rail is provided along each edge of the lagging to safeguard the men working on the false-work, the maximum height being nearly 135 ft. The forms 18 ft. wide, about 8 to 11 ft. long and 5½ to 9½ ft. high, are built with 2-in. tongue and groove planed horizontal boards set on the lagging in the positions indicated by the numbers showing the sequence of construction of the voussoirs. The transverse faces of the forms are in planes radial to the intrados of the arch and all four sides are made with panels having transverse cleats. The inclined faces of the forms are heavily braced by inclined struts to 6x12-in. cleats thoroughly bolted to the lagging.



Centering for 233-Foot Arch.

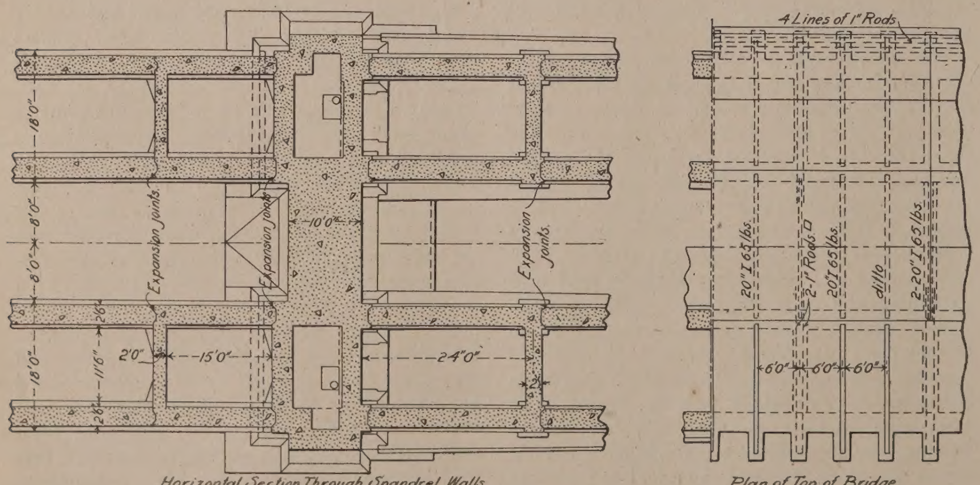
Except at the crown the surface of the lagging is an inclined plane of varying steepness, much of it exceeding the angle of friction. In order to prevent the voussoirs from slipping together before the keys between them are filled, sets of three concrete struts were built between adjacent voussoirs and transmitted the dead load stresses continuously from crown to skew-backs after the mould braces were removed. The struts were 18x24 in., 15x20 in., 12x18 in., in three successive keys from the skew-back up. When the keys were filled in the struts remained in position forming part of the permanent arch ring.

As some of the voussoirs weigh as much as 170 tons each and are seated on steep inclines the workmen were distrustful of the frictional resistance of such as were placed before the lower ones and therefore could not be supported by concrete struts, so, to inspire in them a feeling of absolute security three lines of 1¼-in. steel longitudinal bars, curved parallel to the intrados were bedded into the concrete at the mid line of the arch ring from the crown to the quarters providing balanced anchorage for all the blocks engaged. The rods were made in convenient lengths and their overlapping ends had nuts bearing on reaction plates in radial planes.



Floor Details of Walnut Lane Bridge.

The 1:2:5 concrete for the arch ring was delivered to the voussoir forms by the cableway in four 1-yd. bottom dump Stuebner steel buckets, which delivered it directly into the voussoir moulds where it was spread and spaded by two ten-men gangs, who also placed in it one-man Conshohocken flat stones with a thickness equal to about one-fourth of their average dimension. These stones were placed edgeways to the lagging in radial planes as close together as possible. They were bedded in the concrete and worked down into it. The concrete was flushed against the outer face forms with hand mixed 1:2:3 granolithic mixture delivered in buckets to landing platforms just above the voussoirs from which it was lowered in coal buckets as required. The one-man stones were delivered to the same receiving platform by the cableway skips and packed in so closely as to form about 40 per cent. of the volume of the arch ring. Work was maintained continuously on each pair of voussoirs from the time they were started until completed, days being from 8 to 14 hr. long. The corresponding voussoirs on the opposite sides of the crown were always made simultaneously in order to load the false-work systematically, and about 3 weeks were



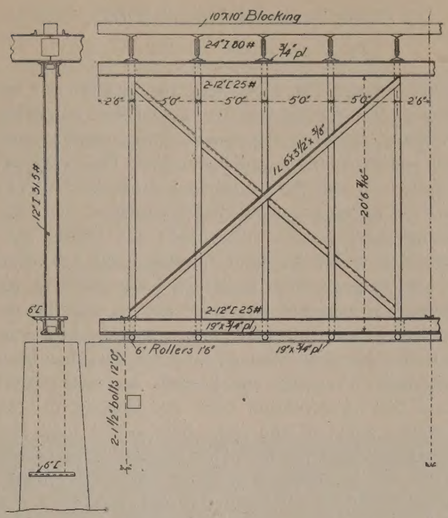
Horizontal Section Through Spandrel Walls

Plan of Top of Bridge.

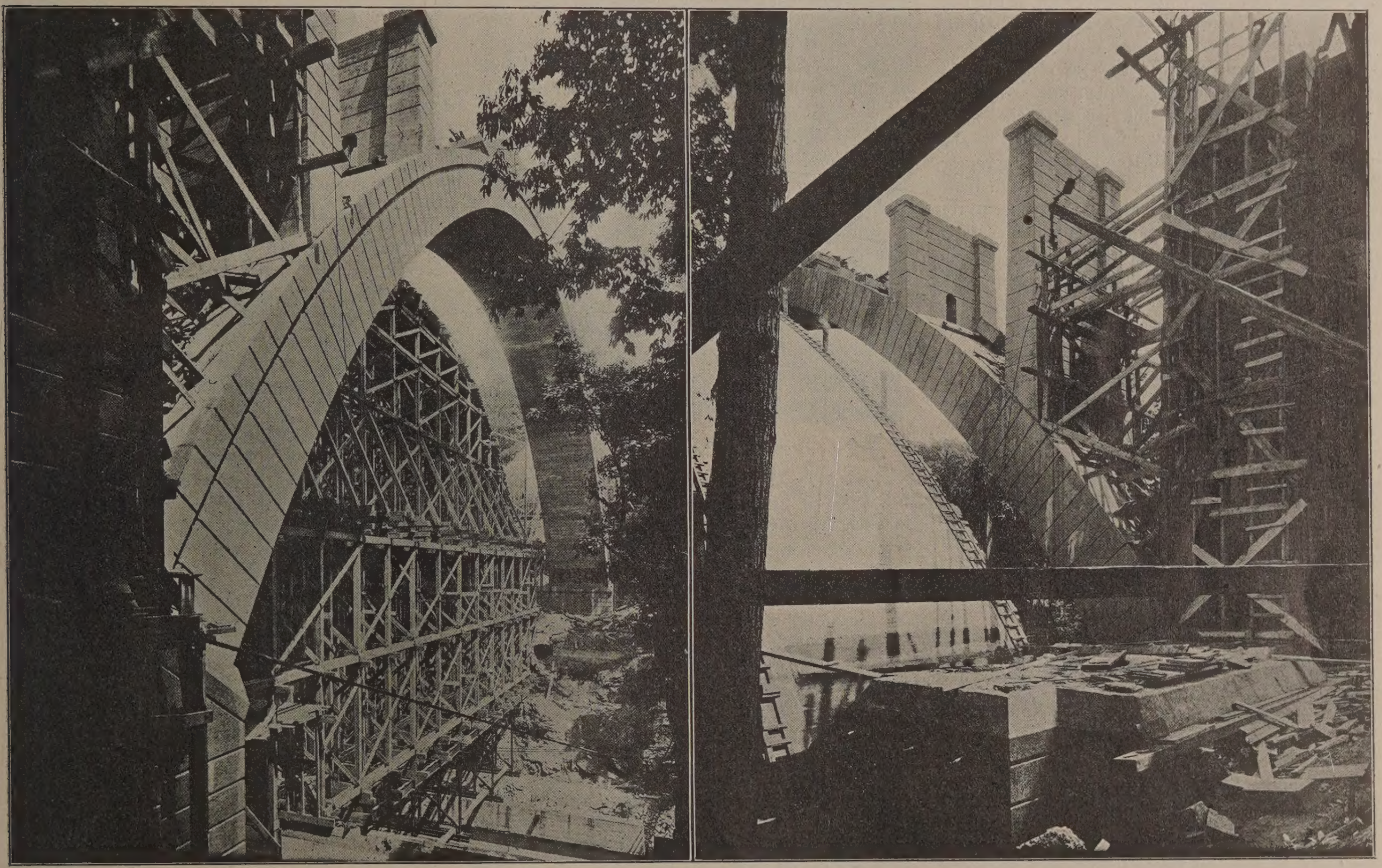
Horizontal Section Through Walls and Top Plan.

required for making all of the voussoirs of the first rib.

The deflection, settlement and expansion of the false-work was considered merely moderate. At the haunches it was noticed that as the successive voussoirs were concreted, the lagging sprung clear of the skew-back voissours making a clearance of perhaps 1-16-in. with them. Vertical wooden gauge rods were suspended from the false-work in four places with their lower ends registering with stakes in the ground and the middle one showed a settlement of 13-16 in. at the crown due to the weight of the first pair of voussoirs which were placed at the crown. Levels were taken daily on the top of the false-work and the ultimate total deflection of the false-work at the crown when all voussoirs were placed was 2 in.



Steel Bent of 233-Foot Arch Centering.



First Rib of Main Arch after Removal of False Work, Walnut Lane Bridge.

The voussoirs were always stripped when they were one day old and scrubbed on the faces. When the last voussoir of the first rib was 14 days old and all settlement had taken place in the false-work and the voussoirs had fully shrunk the 17 keys were concreted as nearly simultaneously as posible. Thirty days later the centering was struck by slacking the wedges. This operation was commenced at the middle and progressed towards each end. Eight men with sledges lowered the false-work sufficiently to free the arch in six hours. This was very successfully accomplished and caused a further settlement of only 1/8 in. of the concrete at the crown of the arch.

After the false-work was clear of the first arch rib the achor bolts connecting the transverse bents to the concrete false-work piers were removed, a 35-ton ball-bearing ratchet jack was set horizontally against the rear end of the bottom sill of each transverse bent of the false-work or substructure and reacted against blocking secured by the anchor blocks in the concrete piers. The jacks were simultaneously operated by two men each and pushed the falsework and sub-structure, having an estimated weight of 900 tons forward on the rollers 34 ft. in three days. The voussoirs were anchor bolted to the concrete piers as at first and the upper and lower sections of false-work were raised on the wedges on both sides until the lagging was at the required position for the second arch rib and the concrete was carried on as for the first rib.

All parts of the structure are concreted in place except the 884 balusters. The latter, about 23 in. long and 10 in. square are cast vertically in cast-iron molds at the rate of 20 daily by a gang of 5 men. The bottom is recessed to engage a projection in the coping to which it is bonded with a vertical steel dowel. At first considerable difficulty was occasioned by cracks appearing just under the upper fillet. These were thought to be caused by the internal stresses caused by the setting and adhesion of the outer portion of the baluster first and were finally overcome by troweling down the sides at the top of the mould when the concrete commenced to set. When 24 hr. old the balusters are taken out of the mould and scrubbed and are then immersed in water where they are kept for one week. They develop a very hard, smooth gray surface with sharp corners that are not inclined to crack or chip and which resemble handsome cut stone work. The reinforced concrete hand rail will be cast in position on top of the balusters in lengths of about 22 ft. with expansion joints between the ends of the rail and the balustrade piers filled with asbestos felt, a device which has proved effective in preventing crushing and distortion of similar hand rails in other bridges built by the same designer.

The contractor's plant has been establised at grade near the Roxborough end of the bridge and comprises office, repair shop, carpenter and smith shops, storehouse, storage bins, concrete plant, stables, derricks and a cableway. Trap rock broken to pass a 3/4-in. screen and be rejected by a 1/4-in. screen is delivered by 15 teams, each averaging 7 trips daily and hauling it 1 1/2 miles from the railroad to a platform at roadway level where it is dumped through double trap doors into a 200-ton hopper bottom bin. Sand is similarly received in a 100-ton bin adjacent to it and both are delivered through bottom gates to the hopper over a bucket elevator driven by a 5-h.p. Reading engine. The buckets discharge on opposite sides of a partition into an elevated storage bin. The bins deliver through 10x12-in. horizontal steel gates to twin charging hoppers with measuring strips on the inner surface to gauge the amount of material required for different proportions of concrete.

Portland cement stored in an adjacent house with a capacity of 1,500 barrels is wheeled from it to an 18-in. belt conveyor which is inclined at a steep angle with the horizontal and is provided with transverse wooden shelves 8 in. wide and about 24 in. apart on which the bags are placed by hand. The belt reverses and deposits the bags on the measuring platform where they are emptied by hand into the mixing hopper. When the hopper is filled the cement man operates the levers that control the hopper gate and delivers its contents to a 1-yd. McKelvey mixer below, a measured quantity of water is added from a barrel and delivered through a foot valve into the mixer. The concrete is delivered from the mixer into 1-yd. steel buckets on flat cars on a 20-in. gauge track about 20 ft. long, the ends of which project about 5 ft. beyond the sides of the concrete tower and clear of it to enable the buckets to be hoisted by the cable-way trolley without danger of swinging against the tower. Granite grits for the 1:2:3 granolithic surface are stored at ground level in a 50-yd. bin adjacent to the concrete mixer and shovelled from it and is chuted to a hand mixing platform in the bottom of the bucket pit where sand and cement are also received and the small quantity of a mixture required is prepared and delivered in buckets by the cable-way.

The 785-ft. Lambert cable-way is anchored at the ends to dead men made with logs in the bottom of a pit covered with a reaction platform loaded with 40 tons of stone. All machinery is operated by steam furnished by the central power plant in which there are installed one 30-h.p. and three 20-h.p. boilers for the concrete mixer, elevators and cable-way machinery. There is also a 10x10x10-in. Ingersoll-Rand air compressor, driving pneumatic hammers used for bush hammering the arch soffit. There are four 10-ton derricks with 60-ft. booms which are moved from pier to pier and are operated by three 20-h.p. Lidgerwood engines and one Mundy engine, each with an individual boiler.

The main quantities are 19,200 cu. yd. of concrete and 96,000 lb. of reinforcement steel in the bridge, 6,000 cu. yd. of excavation, 370,000 ft. B. M. of yellow pine in the falsework, 270,000 lb. of steel in the falsework sub-structure and 800 cu. yd. of concrete in the falsework piers. Whitehall Portland cement has been used on the work. The contract price for the finished bridge is $253,551 and it is required to be finished in 18 months. Excavation was commenced August 1, 1906, the first concrete was laid September 20, the construction of the falsework was commenced January 1, 1907, and finished April 1. The concreting was commenced on the first main arch rib April 29, and finished June 7, the rib was swung July 22, and the centering was removed for the second rib August 3. An average force of about 125 men is employed and the largest amount of concrete laid in one day was 100 yd.

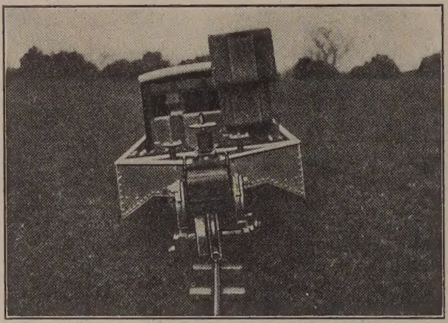
Great care is taken to execute the work in the best possible manner and make it conform strictly to specifications, efforts in which the contractor co-operates heartily with the engineer. One inspector is constantly stationed at the concrete mixing platform and one at each concreting gang. All cement is sampled at the storehouse and is not used until after it has successfully pasesd a 7-day test. Six inch concrete cubes are made as samples of each day's dork for test in the city laboratory. The bridge was designed and its construction is supervised by the Bureau of Surveys of the City of Philadelphia, Mr. George S. Webster, chief engineer, and Mr. Henry H. Quimby, assistant engineer in charge of design and construction of bridges. The contractors are Messrs. Reilly & Riddle, the general supervision of the work is under the personal direction of Mr. T. H. Riddle. Mr. Moriz Bernstein is their engineer and Messrs. Chambers Lattimer and O. G. Hoover are assistant superintendents.

A Railroad in Nigeria, Africa, will be constructed by the British colonial government to develop the resources of the country, and in particular to stimulate the cotton growing industry. The road will be about 400 miles long.

The Brennan Monorail Car.

By C. O. Burge, M. Inst. C. E.

Some years ago there was an agitation for reducing the standard gauge in railway extension in many parts of the world, unfortunately only too successful in many instances. This was advocated on the three principal grounds that (1) friction on curves would be diminished, thus enabling sharper ones to be used; (2) lighter construction would be made possible, and (3) dead weight in proportion to paying load would be reduced. Experience has since proved that by reducing gauge the first object, which, however, is only really important in hilly districts, has been practically the only one gained, for strength of road bed construction does not depend on the distance apart of the rails, but on the load and speed, whether on broad or narrow gauge; and lastly, aside from exceptional cases, the loads, especially in new countries with raw produce of low specific gravity forming much of the freight, are more favorable to the ordinary gauging; that is to say, if the narrower cars were to be loaded to their full weight-carrying capacity, by wool, cotton, cattle and similar light freight, the height would cause instability, while full loads as to both weight and capacity can be, in such cases, conveyed safely by the wider car. Now, however, when Mr. Brennan, of torpedo fame, ingeniously and boldly proposes to reduce the gauge to zero, the first advantage, reduction of curve friction, is secured to a very much larger degree; the second object is partly attained, and the third very much more so, for, through the action of the main feature of the invention—the gyroscopic principle—perfect stability independent of width is attained by the automatic preservation of the position of the center of gravity of the car and its load relatively to the single rail support. That the invention, notwithstanding some obvious drawbacks to which we shall refer later, has a good deal to say for itself, is shown by the fact that the Indian government, which makes its own railways and has an experienced consulting engineering staff in London, has, after due inspection, advanced £6,000 to Mr. Brennan, to assist him in experimental work. When, therefore, on Aug. 10, the present writer, with about half a dozen other experts, visited, at Mr. Brennan's courteous invitation, his beautiful home in Kent, England, to see further experiments with a model car, he was intensely interested.



Effect of Side Loading.

The general principles of the application of gyroscopic action in this case, have already been widely published, and it is only necessary here to say that in the 5 ft. 9 in. by 1 ft. 6 in. model car, two 5-in. vertical wheels, normally parallel to each other and to the length of the car, are revolved in opposite directions at a speed of 7,000 revolutions per minute, this proceeding whether the car is in motion or not. This stability mechanism occupies but little space and is placed concealed under the seat of the cab in the front, the weight being only 5 per cent. of the gross load. The particulars of the automatic device by which the gyroscopes recover their parallelism after the required couple has been exerted, have not been published and are believed not to be yet perfected, but the effect is something not far short of the miraculous. The loading was all heaped up on one side of the car, and as each piece was transferred, the vehicle arose automatically on that side, so as to throw the center of gravity vertically over the rail, while when the car was tilted over by hand and then released, it recovered its position at once, showing how oscillation of speed was dealt with by the gyroscopic influence. Similarly, when the car was put in rapid motion over one of the numerous sharp curves on the model line, the centrifugal force generated was at once automatically opposed by a righting tendency, and the requisite cant inwards, ordinarily effected by super-elevation, was developed. The road wheels are grooved and are fixed to a pair of tandem two-wheel bogies, one at each end, pivoted for vertical as well as horizontal curves on the track, so that inequalities in level are not much felt—the motive power for these, of course, may be that most suitable for the service required.

The car went round easily a curve so sharp that while the leading bogie had passed over it, the trailing one had not reached it, though the tangents of the curve were at right angles, the axis of the car forming the chord of the curve from springing to springing. In fact, the small rigid wheel base of the bogie alone limits the curvature, and mountain lines on this system can be constructed with a facility as regards curves, gradients, and cost of works, to which even the narrowest two-rail lines cannot approach, while the width of the car, as far as stability is concerned, is unlimited in the one case, and not in the other. But there is not only the practicability of negotiating unusually sharp curves, but the almost entire abolition of frictional resistance on all of them, on the monorailway. So much for curvature.

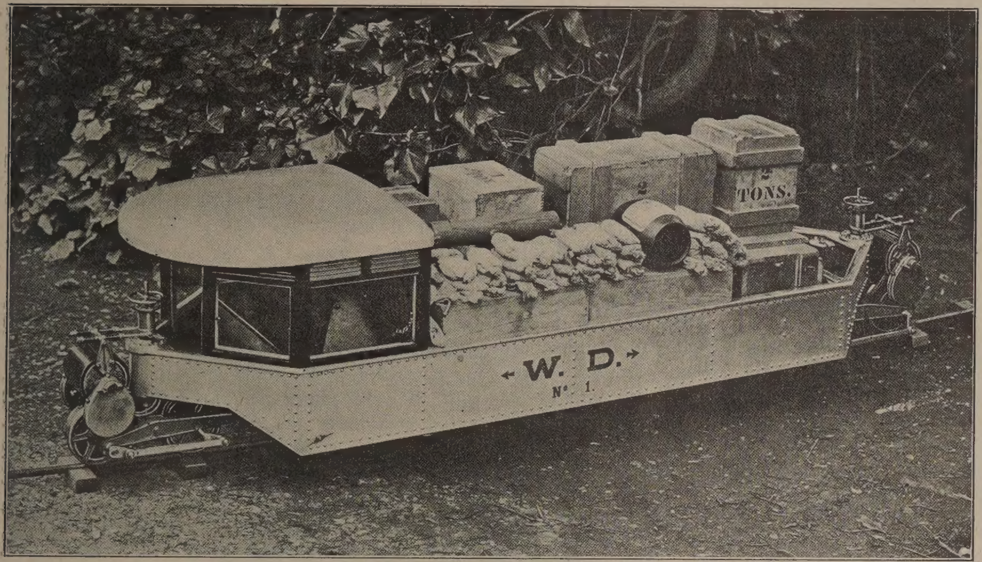
As to the second point, it has been claimed that inasmuch as one rail only is required, the road bed may be lighter, but this is the old fallacy of the narrow-gauge advocates, the weight of rail and bearing of tie being approximately regulated by the weight and speed of the load irrespective of the number of the rails or their distance apart from each other. We say approximately, for the double rail construction suffers under the oscillation arising from the practical impossibility of keeping the two rails exactly level transversely. Hence, each rail has to be strong enough to bear more than half the load, with its impact, while the single rail cannot have any more than the whole to deal with. The same considerations apply, with modifications, to bridges, for some sort of floor would be necessary in any case, and in large structures wind stresses must be provided for, so that the usual width could not be much diminished.

On the whole, not much advantage would be gained in this system by cheapening cost of road-bed.

On the third point, as to economy in dead loading, it is very clear that stability being insured by Mr. Brennan's apparatus, the capability of the car as regards weight and space can be made harmonious, and the machine can be thus worked to its full power in both ways. As this result is, on the whole, well attained on the standard and wider gauges, this particular advantage is limited to countries where the narrower gauges exist.

Generally, as far as the system can be judged at this stage, its chief scope will be for lines in mountainous countries in which economy of construction through reduction of curvature, and of traction thereon, will be great. The absence of the effects of the oscillation which limit velocity on the two-rail line may be a recommendation for the adoption of the monorail for high speed interurban service also.

Mr. Brennan is now constructing a car approximately eight times, in linear dimensions, the size of the model, in which he calculates that the gyroscopic speed will be reduced to 3,000 revolutions per minute, though he states that 850 is enough to maintain stability. He has had placed at his service land adjoining his property belonging to the British War Department, on which to build an experimental full-size mono-railway, when the investigations, now being gone into for improvement, will have their full effect, possibly within a year or eighteen months.



Side View of the Brennan Experimental Monorail Car.

There is no doubt, from the experience gained, of the absolute perfection of the gyroscopic action while in operation, and if the small motive power requisite to produce it happened to fail, the gyroscopes, being on ball bearings and working in vacuo, would retain sufficient momentum to revolve at a high speed for a long time, giving ample opportunity for providing stability by other means. But there is the possible failure of the gyroscopic mechanism itself, or of the ball bearings, unlikely in the latter case in the absence of crank or belt stresses as in the case of an ordinary flywheel, but still a contingency, though remote. However, no human contrivance is infallible, and such an occurrence is certainly not more likely than that of an axle breakage, impossible in the mono-rail car, which we risk every day and which would equally lead to disaster.

The danger might be got over by providing a double set of gyroscopes for each vehicle, but this of course involves extra space being sacrificed, and extra cost in construction, the necessity of one set in each car being sufficiently objectionable in these respects. Trial on a much more extensive scale will alone show whether the undoubted advantages gained will not be counterbalanced wholly or partially by the extra cost of construction and maintenance of the gyroscopic mechanism.

The adoption of the monorail for branch feeders to a main line of the ordinary type and gauge, has one advantage over those of narrow gauge, which latter system has been, somewhat unwisely, carried out in some countries, thus involving transhipment, and what is more, isolating the branch rolling stock. This advantage arises from the possibility, with some slight modifications at stations, bridges, tunnels, etc., of running the monorail vehicles over one rail of the main line, so that transhipment of freight, difficulty of access to workshops, etc., inherent in the other case would be avoided.

There are certainly sufficient possibilities in the new invention to cause all engineers concerned in railway construction and working to await with deep interest, the result of the larger experiments which are promised.

A Tar and Feathers Road.

Road improvements in Athens, N. Y., have not found favor with the conservative majority of its people, and the progressive element considered strong measures necessary. One morning the center of the town's leading thoroughfare was found planted with several rows of cabbages. The town council was stirred to action and consulted a local inventor as to what should be done. He decided that the street had a gravel bottom and by pouring tar on it a good pavement would result. He was so confident in the success of the method that he offered to furnish the labor if the council would supply the tar. Two blocks were covered in this way on the first day, but the conservatism of the town revolted and the next morning the street was found coated with feathers.

An Infiltration Water-Works Intake Under the Ohio River.

An infiltration water-works intake built of well point strainers buried in the sand bottom of the Ohio River, has been in successful operation for nearly a year in connection with the system of the Owensboro, Ky., Water-Works Co. The system is owned and operated by this company, embracing a pumping station on the bank of the Ohio River and distribution mains from which the city of Owensboro is supplied. The pumps in the station are in dry wells and formerly drew water directly from the river. While the raw river water is unsatisfactory for domestic purposes during a large part of the year, and at certain times it is even dangerous for such uses, when clarified it furnishes a very satisfactory supply. Although the company desired very much to secure better water, it preferred not to build a filtration plant of any type, or resort to any means of purification which would require maintenance and operating expenses, if a desirable supply could be obtained by other means. A broad, deep bar of clean sand and fine gravel which exists on the opposite side of the river from the pumping station, has its surface kept comparatively free of mud and silt at all times by the current in the river. After considerable investigation the decision was made to build an infiltration intake in this sand bar near the line of extreme low water in the river, and to connect the intake with the station by a suction main laid in a trench in the bed of the river.

Laying Cast Iron Pipe in 24-Feet of Water in the Ohio River.

The suction main which extends across the river from the pumping station to the intake consists of 20-in. hub-and-spigot cast-iron pipe, with a flexible joint to each fourth 12-ft. length. This main is laid nearly at right angles to the channel of the river and connects at the outer end through a 20x16-in. tee with a 16-in. cast-iron pipe laid at right angles to it and in both directions from it. This 16-in. pipe extends 175 ft. downstream and 225 ft. upstream from the end of the suction main. A four-way special connection, having two 8-in. and two 16-in. legs, is placed in the 16-in. pipe every 50 ft., starting 25 ft. on each side of the end of suction main. A 12-ft. length of 8-in. cast-iron pipe is placed in each 8-in. leg of these connections, forming at each 50 ft. two laterals at right angles to the 16-in. branch of the 20-in. suction main. Flexible joints are used on the 8-in. laterals. An 8x6-in. tee connection is leaded into the end of each of the latter and carries in each 6-in. leg a standard 6-in. No. 8 Cook well point strainer, 16 ft. long. The thirty-six strainers thus provided are, therefore, in two rows parallel to the 16-in. branches from the 20-in. suction main, the two rows being 28 ft. apart on centers and the ends of the strainers in the rows 18 ft. apart.

The strainers have the usual slots at right angles to their axes, cut in them, the slots in the strainers used being 0.008 in. in width. The whole system of strainers and connections is buried 4 ft. 7 in. below the natural surface of the bar of sand and fine gravel, the backfill being carried 18 in. above that surface to allow for settlement. A bed of filtering sand and gravel 60x450 ft. in plan and 4 ft. 7 in. deep is thus obtained. Owing to the location of the sand bar relative to the position of thr river channel, and to the current over the bar, the surface of the latter is kept clean at all times so no trouble is expected from the sand bed becoming filled with silt. In fact, during the time the system has been in service a clear, safe water has been obtained, which it is believed will improve after the sand over the strainers has had an opportunity to settle. The cost of operating the pumps in the station has been considerably reduced by the removal of the sand from the water. Formerly the pump plungers had to be packed once a week, but they have been packed only once since the intake has been in service and are still in good condition.

The important feature of the infiltration intake is its capacity to produce pure, clear water from the river at all stages of the latter and all conditions of the raw river water, without expense after the installation was made. Although the details of this intake are a departure from what has been done along these lines, they could be utilized in obtaining a supply from a river wherever a sand bed formation of suitable character is available.

The intake has an estimated capacity of 12,500,000 gal. per day under normal conditions, some allowance being made for a reduction in capacity. The 20-in. suction main is capable of supplying 5,000,000 gal. of water per 24 hours under economical operating conditions at the pumps. The average daily consumption supplied by the Owensboro water system, however, is only 2,500,000 gal., so it is believed the present intake will furnish an adequate amount of water for some time to come.

The intake and suction main were both laid with the assistance of a diver, from a scow on the surface of the river. The original intention had been to place the intake 48 ft. toward the shore from the extreme low water line. Conditions existing at the time the work was done necessitated a change of plans, however, the intake being placed about 50 ft. off shore from the low water line. The site of the intake was excavated to the desired depth with a floating dipper dredge. The latter was also used in opening up the trench for the 20-in. suction main which was laid at a minimum depth of 2 ft. below the surface of the river bed. On the Kentucky side of the river a ledge of sandstone rock was encountered for a length of 150 ft. in making the trench for the suction main. An 8-in. wrought-iron pipe, fitted with a sharp point and heavily loaded, was used to break up this rock by dropping it from a hoisting block on the scow used in laying the pipe. The rock was successfully broken out in this manner and was then removed by the dredge.

All of the work on the suction main and the intake was carried on with no small amount of difficulty. The water was from a minimum of 6 to 30 ft. in depth to a maximum of 10 ft. above that level during the time the under-water work was in progress, the current varying from 3 to 6 miles an hour at different places. The dredging work was done with the almost continuous assistance of a diver who worked at great disadvantage in the deep water and swift current. In the section of the trench for the suction main where rock was encountered, the operation of the pointed and weighted pipe used in breaking the rock was done under the direction of the diver, and the latter also directed the removal of the rock.

The suction main and intake were laid from a 24x80-ft. scow carrying a guyed A-frame at one end and a hoisting engine. The suction main was laid in sections consisting of four 12-ft. lengths of pipe, extending from one flexible point to the next. The three hub and spigot joints between the four lengths of pipe to each section were made on the shore on skids. The ends of the section were then blanked with wooden bulkheads to assist in floating it when first placed in the water. After the scow had been anchored over the position the section to be laid was to occupy, the section was swung over its designated site by the derrick and lowered to place from a triple block on the latter. The flexible joints between the sections were then made by the diver.

The intake pipe and strainer system was laid in sections 50 ft. long, a flexible joint being placed every fourth length of the 16-in. branches from the suction main. These sections were assembled on the scow and lowered into place from the derrick, after which the strainers were placed by the diver. High water interfered with the backfilling over the intake, which was finally done with a suction dredge.

A 12x12x8-ft. valve chamber built of concrete was built at the end of the suction main. The latter leads to a 20-in. four-way connection in the valve chamber, a 16-in. and a 20-in. line leading out of two legs of this connection to the pumps. A 20-in. pipe extending to the river directly from the fourth leg of the connection provides means of obtaining a supply in case the suction main is out of service. The valve chamber is just inshore from the low water line and is submerged 50 to 60 ft. during high water. Sediment and drift are kept out of the chamber by a heavy timber cover well anchored to its side walls. A hydraulically-operated valve, manipulated from the pumping station, is placed on the 20-in. emergency intake and one on the 20-in. pipe leading to the pumps. The usual arrangement of such valve chambers along the Ohio River, where high water is about 70 ft. above low water level, is to build a tower over the chamber to a point well above high water, this tower being connected to the shore by a bridge. The submerged valve chamber with the hydraulically-operated valve avoids such a tower and bridge and has been satisfactory in service.

The infiltration intake, suction main and other improvements to the system were designed by Mr. Owen Ford, consulting engineer of St. Louis, Mo., and were installed under his direction. The suction main and intake were laid by Mr. Joseph G. Falcon, of Evanston, Ill., who also furnished the flexible pipe joints used.

The Railways of the World had a total length of 563,772 miles on Jan. 1, 1906, according to German statisticians. Of this amount 215,713 miles were in the United States and 192,248 miles in Europe. New construction during 1905 added 12,524 miles to the total, of which 2,485 miles were in Europe. Germany showed the largest increase, building six times more road than Great Britain. Considerable progress was also made in constructing railways in Africa, particularly in the German possessions. The compilers of the statistics estimate that the entire capital invested in the world's railroads amounted on Jan 1, 1906, to 43⅓ billion dollars.

Constructing a Sewer Under the Brooklyn Subway.

The tracks of the Rapid Transit R. R., in Flatbush Ave., Brooklyn, will pass through a standard rectangular reinforced concrete four-track subway to the intersection of Flatbush and Atlantic Avenues where they will enter a station communicating with the adjacent Long Island R. R. Depot. At this point a short depressed spur will be built dropping under the grade of the main tracks and crossing them to provide for a future connection with a subway which may hereafter be built on Fourth Ave. At this point a 15-ft. circular brick sewer coming down Hanson Place, is deflected about 45 deg. and continued through Fourth Ave., at a clear depth of about 23 ft. from the surface of the streets to the top of sewer. The straight portion on Fourth Ave. is low enough to pass clear beneath the main tracks of the subway, but is not low enough to clear the depressed tracks, the center lines of the subway for the latter and of the sewer itself being about in the same horizontal plane. As the grade of the sewer could not be altered it was necessary to deflect it for a short distance to clear the sub-subway before the construction of the latter was commenced. The new work is very simple and consists merely of a curved by-pass 290 ft. long forming two sides of a triangle connected at both ends with the old sewer and permitting the intersected portion of the old sewer to be removed to leave clear space for the construction at the same level of the single track depressed subway spur which will at present terminate in the triangle enclosed by the two sides of the by-pass and the connecting center line of the old sewer. Practically the new construction and the whole of the by-pass is permanent construction and it is built like regular standard sewer work and will not be modified unless the depressed spur is hereafter continued to connect with a subway in Fourth Ave., in which event it will intersect the by-pass and it will be necessary to cut off one side of the latter and continue the other or up-stream side for some distance parallel to the subway through Fourth Ave., until a point is reached where the ascending grade of the subway carries it high enough for a connection to be made between the by-pass and the existing old sewer, thus virtually lengthening the present by-pass as occasion may demand. On this account the angle of the by-pass where such a future extension may be made is indicated by dotted lines in the general plan and is there noted as a future connection.

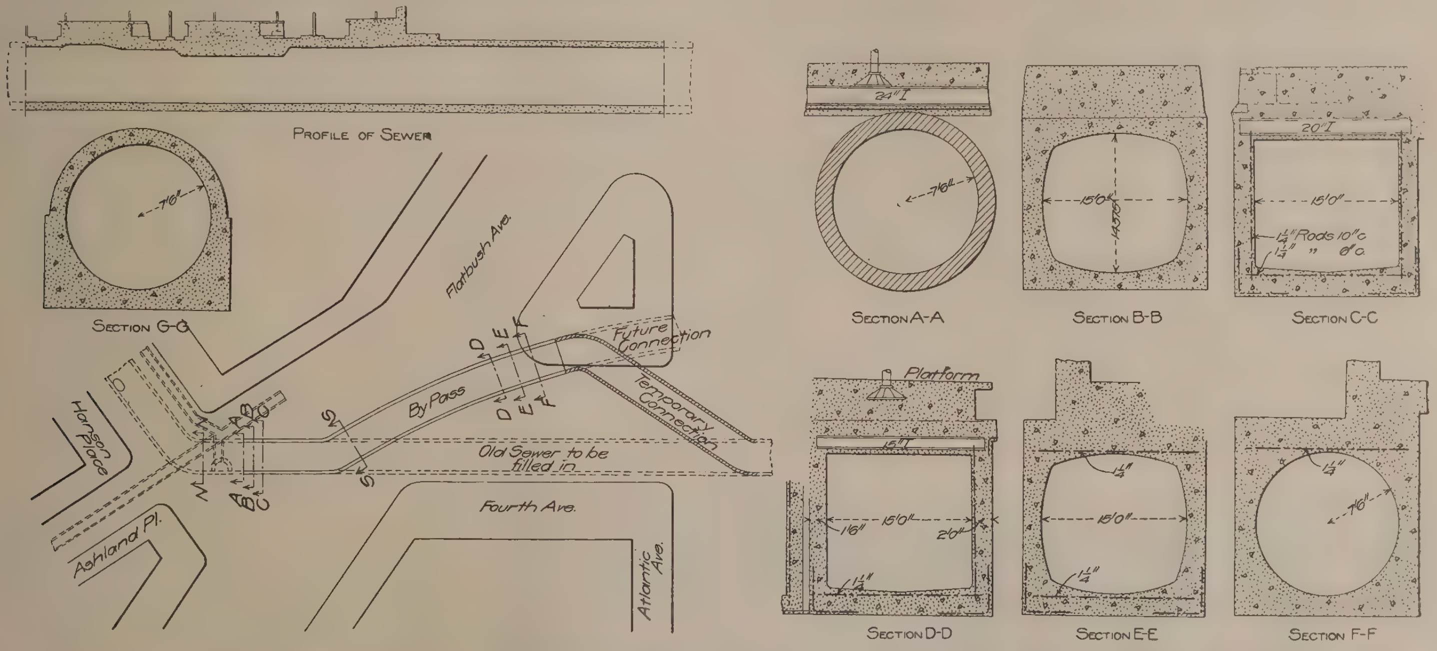
In order to maintain the grade of the sewer and to carry it through the limited head-room under the main subway it was necessary to increase the cross-sectional area by transforming it from a circle to a rectangle for a length of about 172 ft., beyond which it resumes the regular circular section. The change of cross section at each end is made in a 20-ft. length of concrete construction which enables the curved surfaces to change smoothly and gradually to flat surfaces. The rectangular cross-section has an inside width and height of 15 ft. and 12 ft., respectively, thus affording a somewhat increased area. The invert and vertical side-walls are reinforced with 1¼-in. square rods 6 in. and 10 in. apart on centers. The rectangular section corresponds closely with that of the depressed subway and is built adjacent to it, resembling very much a twin structure, both structures pass underneath the tracks and station of the main subway and support on their roof numerous of the latter structure. The roof of the sewer has a variable thickness and elevation according to the requirements of the structure above and it is formed with a solid concrete slab from 2 to 3 ft. in thickness, which is carried on I-beams with a depth of 15 to 20 in., and a spacing of 7½ to 24 in., according to the superimposed columns and other loads. Except for these irregularities and special features the sewer design is simple and the principal features of interest are comprised in the methods adopted for constructing it and for safeguarding the old sewer and maintaining its service uninterruptedly during the new work.

The sewer carries so much storm water that it is sometimes under pressure sufficient to blow off the man-hole covers, and it was considered unsafe to demolish it completely in ordinary open trench. A method was therefore devised for reconstructing the invert before disturbing the roof arch at the two points where it unites with the ends of the by-pass. Transverse falsework bents of 10x10-in. timbers, 15 ft. apart, were seated on the invert of the old sewer and supported a pair of continuous longitudinal girders 5 ft. apart on centers, each of them having a T-shaped cross-section made with a 20-in. I-beam and a 15-in. channel, both breaking joints and spliced with cover plates bolted on the webs. These girders carried upper transverse bents 5 ft. apart, made with vertical and inclined posts supporting arch-like transverse timbers, carefully wedged against the brick work and forming altogether a system of underpining similar to that used by the same contractors for the rectification of the Battery tunnel which has been described in several articles published in these columns.

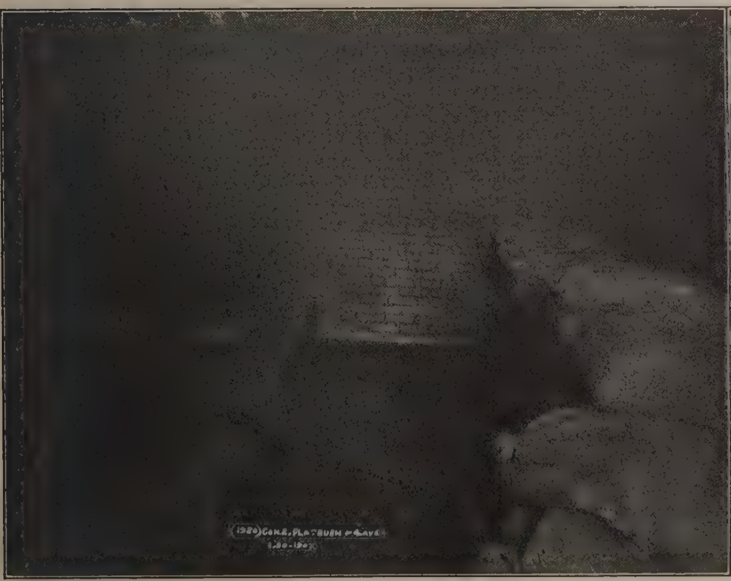
After the completion of the underpining of the sewer roof at the upper end of the by-pass a dam about 4 ft. high was built across the sewer invert with bags of sand and cement, and through the bottom of it was carried one end of a riveted steel pipe 3 ft. in diameter and 64 ft. long, serving as a flume to carry the ordinary flow of the sewer. The upper end of the pipe was chained securely to a 12x12-in. transverse beam with the ends concreted into recesses cut in the sides of the sewer to serve as an anchor and resist the tendency to displacement, which was found to be considerable. The lower end of the pipe emptied into the old sewer through a similar dam, thus allowing the space between the two dams to be pumped dry and the inverts cut out and connected with that of the by-pass.

At the point where the change in cross-section of the old sewer commenced, just above the by-pass, a 7½-ft. length of the old brick invert was cut out to a level a little above the springing line on both sides, the old brick work removed and the necessary excavation made and carefully sheeted with horizontal boards and vertical rangers braced by inclined struts to the feet of the underpinning bents. The new concrete invert was then built and care was taken to have the reinforement rods in the side wall project far enough above the surface of the concrete to form 4-ft. lap joints with the reinforcement bars in the upper part of the sewer. Alternate 7½-ft. sections of invert were thus built for the full length required and after the concrete was properly set the roof arch was carried from them by means of bracing, reacting against longitudinal timbers with vertical shores placed between the jack screws. The transverse false work bents were then shifted to seats on the new invert and the intermediate sections of old inverts were replaced by new inverts built in the manner already described, the remainder of the roof was supported from the side walls, transferring the roof weight entirely to the vertical shores.

Several elevated railroad columns are located over the line of the sewer and in order to carry them and provide clearance for the excavation and construction below street surface, nine 6x6-ft. pits were sheeted down from the surface of the street to the top of the sewer arch



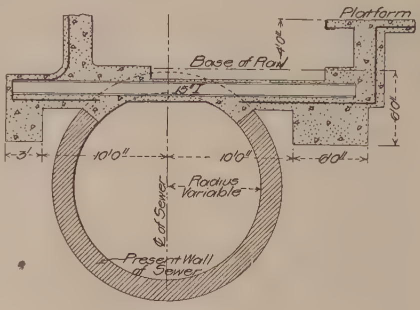
Location, Profile, and Principal Sections of By-Pass Sewer.



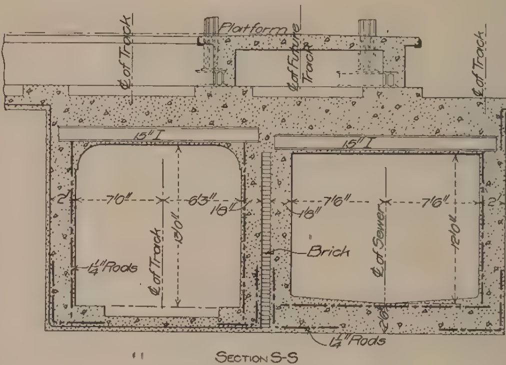
Anchorage of Steel Pipe.

Timbering over Old Sewer.

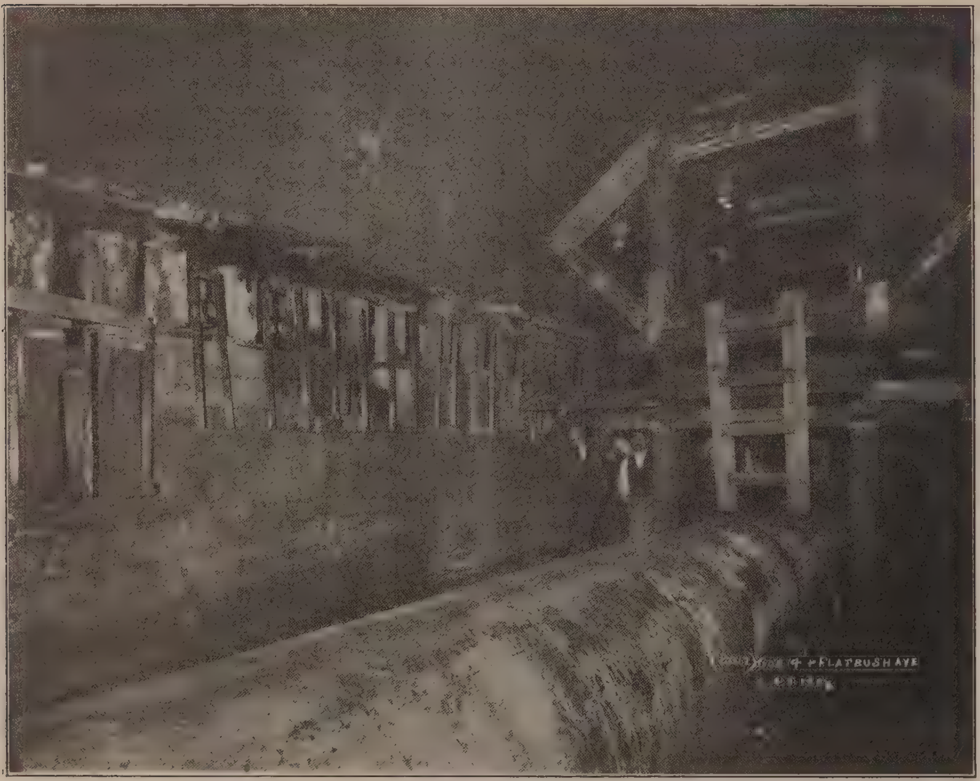
which was cut through and a corresponding hole cut through the invert of the sewer and the excavation continued a little below subgrade of the new sewer. The bottom of the excavation was concreted to form part of the footings for the new invert and receive a timber grillage on which were seated four 12x12-in. vertical posts extending through the sewer roof arch where they were enclosed with concrete completely sealing the hole and capped to receive two 12x12-in. timbers about 22 ft. long, which reach to the surface of the ground. Here they were capped and braced to receive one foot of the adjustable A-frame, described in previous articles, for the support of the main transverse girder of the elevated railroad structure. The Elevated Railroad column remains suspended from the transverse girders after its footing had been removed until the new sewer and subway above it is constructed and a pier built on the I-beam roof girders of the latter is ready to receive the column pedestal. A full width trench was then sheeted down in the usual way on the center line of the sewer, the old roof arch removed and the new roof constructed, completing the new sewer.



Old Sewer under Subway.



Sub-Subway and By-Pass.



Underpinning for Sewer Roof and Temporary Pipe.

The old sewer thus replaced was built about 17 years ago by the Anderson & Barr pilot method with its brick lining constructed inside a riveted steel shell with segments about 15 in. wide and 3 ft. long, made of ⅜-in. plates and 2x3x¼-in. flange angles. These were found to be little rusted from their long exposure to the comparatively dry soil and many of the ordinary wooden barrel staves used as poling boards in the original excavation were found in perfectly sound condition. There were, however, many cavities unexpectedly encountered in the earth just above the old sewer, some of them having a capacity of 6 cu. ft. or more, one of them being so large that two men fell into it up to their waists. Much of the planking used as a cradle for the invert was also found perfectly sound, although it had not been continuously saturated.

Unusually heavy pressures were developed against the sheeting and it was necessary to provide extra numerous and heavy rangers well braced by cross-struts and diagonals. The by-pass sewer between its connections with the old sewer was entirely built in open trench, the invert being completed before the construction of the roof was commenced. No difficulty was encountered from ground water and pumping was only required in cases where excessive storm water was delivered by the old sewer and flooded the excavation. All water and gas mains and other conduits encountered were supported from beams and girders across the top of the open cut, and no special difficulties except those already described were encountered in the construction which involved about 12,000 cu. yds. of excavation, 200 cu. yds. brickwork and 1,650 cu. yds. of concrete made with 1-3-4 Portland cement, mixed on the surface of the ground and delivered where required through 8-in. galvanized iron chutes. The excavated material was removed from the trench in 1-yd. steel buckets handled by a mast and boom derrick, operated by a Lidgerwood hoisting engine, and was dumped into wagons in the street and into cars provided by the Brooklyn Rapid Transit Co., and carried away as fast as hoisted. As a matter of convenience part of the depressed subway alongside of the sewer by-pass was built at the same time as the latter, although independent of it and part of the old sewer was demolished to give clearance for it, the remainder of the old sewer remaining intact beyond the upper end of the by-pass. The sewer work was commenced Oct. 18, 1906, and was completed July 15, 1907.

The sewer work was designed and its construction supervised by the engineering department of the Rapid Transit Railroad Commission, Mr. Geo. S. Rice, chief engineer; Mr. Alfred Craven, deputy chief engineer; Mr. Sverre Dahm, general inspector of designs. Mr. Amos L. Schaeffer, division engineer, and Mr. Thad. L. Wilson, assistant engineer, in charge of work The Rapid Transit Subway Construction Co., Mr. George H. Pegram, chief engineer, and Mr. Percy Litchfield, division engineer, are the general contractors. The work was executed as a sub-contract by Messrs. Cranford & McNamee, Mr. J. C. Meem, chief engineer, and Mr. M. B. Loonie, superintendent.

Cantilever Construction of the Wear Bridge.

Two tracks of the North Eastern Ry. of England will shortly be carried over the River Wear on the upper platform of a double-track bridge which, with its approaches, has about 9,000 tons of steel in the superstructure. It includes a 330-ft. clear channel span, 85 ft. above high water, and three 200-ft. approach spans. The double inter-section riveted trusses of the channel span have horizontal bottom chords and curved top cords and are 45 ft. deep at the center. They are 32 ft. apart on centers and have cantilever floorbeams about 64 ft. long, with sidewalks outside the trusses and a street car track and roadway between the trusses. The trusses have three webs in the top and bottom chords and a center rib in the vertical post.

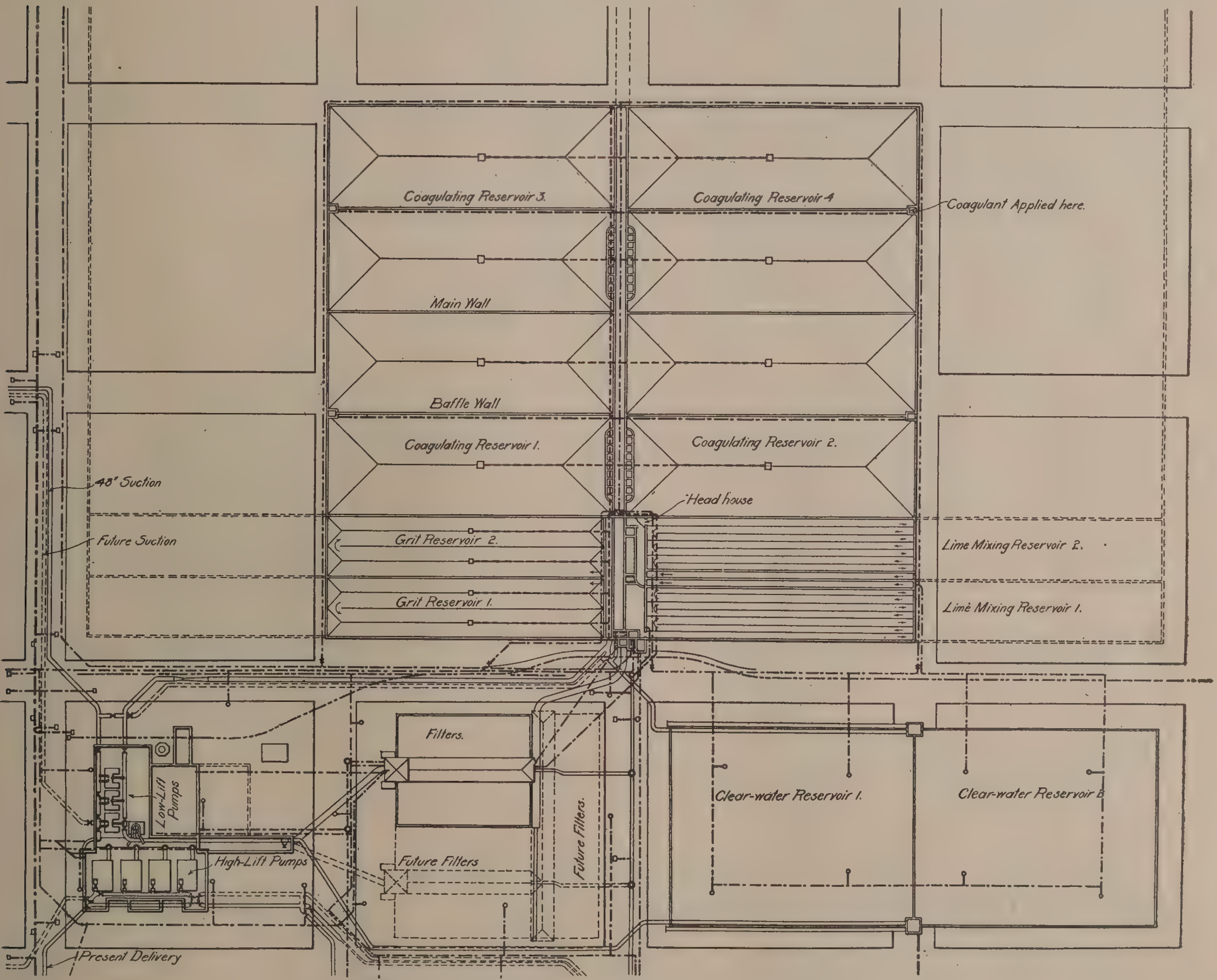
The work is chiefly interesting on account of the method of erecting the center span as a cantilever. The approach spans on both sides were first erected on falsework and from their river ends the main span will be built out panel by panel, with the bottom chords supported by guys from the tops of temporary steel erection towers weighing over 600 tons and seated on the main piers. A large full-width solid floor working platform and a smaller riveting platform will be suspended from and travel on the lower chords.

The Baltic-Black Sea Canal scheme seems to have improved in character, for the U. S. consul at Riga states that Mr. M. S. J. Maxinovitch of the Department of Ways of Communication has been orderd to prepare plans for this route, long the plaything of Belgian promoters. It is intended for use by 900-ton barges, and in its length of 1,525 miles there will be numerous locks and canalized river sections as well as strictly artificial canals. The construction of this waterway will also permit a large amount of power to be developed at several places along the Dwina and Dnieper Rivers.

The Water Purification and Softening Works at New Orleans, La.

In connection with the extensive water works now under construction at New Orleans, La., two plants for filtering and softening the Mississippi River water are being built, of 40,000,000 and 4,000,000 gal. nominal daily capacity, respectively. They are similar in their general plan of construction and operation, both being designed to reduce the sulphate or permanent hardness as well as the carbonate or temporary hardness and both using mechanical filters to remove the precipitates resulting from the softening process. Sulphate of iron will ordinarily be used as a coagulant.

The larger plant will cover an area about 1,000 x 1,350 ft. It comprises a combined low-lift and high-lift pumping plant; two 72x338-ft. grit chambers, 18½ ft. deep; two 72x320-ft. lime-mixing reservoirs; four coagulating reservoirs, each about 246x342x12½ ft. deep; ten 31x53-ft. filters; and two 262x311-ft. clear water reservoirs, 14 ft. deep. The various reservoirs and the filters will be made mainly of reinforced concrete and the buildings of brick and concrete. These structures will be founded for the most part on piles, as the average bearing power of the ground at New Orleans is only about 1,200 lb. per square foot.



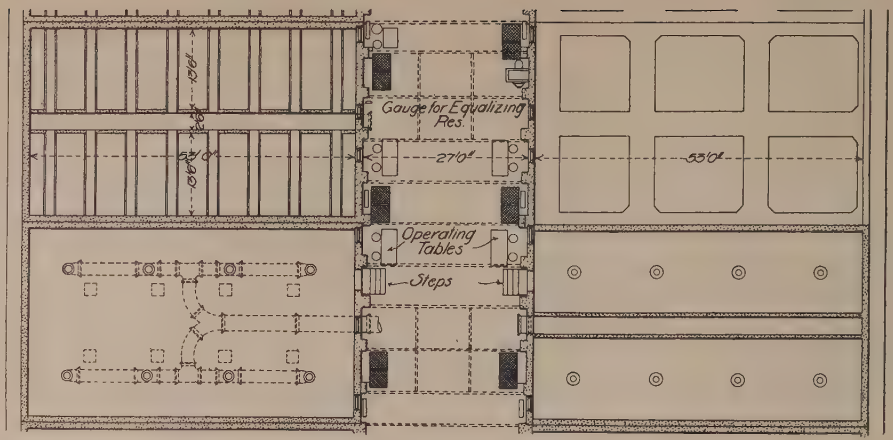
General Arrangement of Water Purification and Softening Plant at New Orleans.

Raw water will be taken from the river through a surface intake, and will be drawn through 4,000 ft. of 48-in. level pipe line, laid with its top about 3 ft. below low water level, by low-lift centrifugal pumps driven by horizontal compound condensing engines. These pumps discharge into a headhouse through a 48-in. cast iron main in which is a Venturi meter. On one side of the headhouse are two grit reservoirs and on the opposite side are the two lime-mixing basins. When the river water is very muddy it will be admitted first to the grit chambers where subsidence will remove the heavier suspended matter consisting of sand and silt. Each grit chamber has a longitudinal baffle wall on its center line which makes the water travel double the length of the tank. The total capacity of the grit chambers is equivalent to about one hour's flow. Returning to the headhouse, the somewhat settled water will pass through submerged orifices into the lime-mixing reservoirs, each of which is divided into sixteen longitudinal passages by seven vertical longitudinal baffle walls and one horizontal baffle midway between the top and bottom of the reservoir. At the entrance to this reservoir, lime will be added regularly to reduce the carbonate hardness and to assist in the coagulation. Soda when necessary for the elimination of the sulphates will also be applied as the water flows through this reservoir, although the latter will not be used save during low-water stages in the river when the sulphates are high. The quantity of chemical solutions added will be automatically regulated in proportion to the varying volumes of water treated by the flow through a series of submerged orifices. The automatic controlling apparatus throughout the plant is one of its distinguishing characteristics.

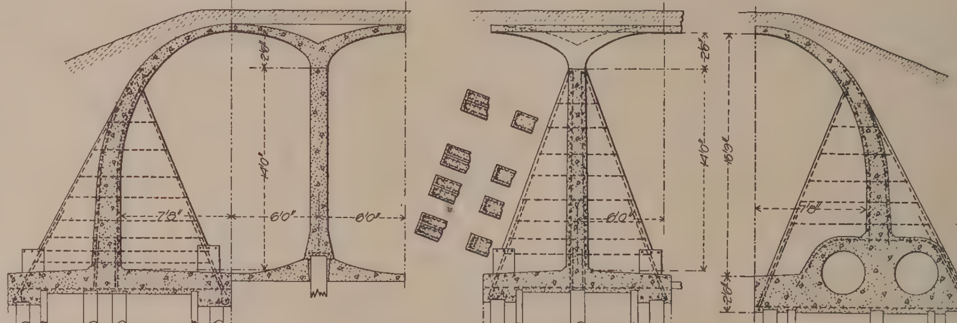
Lime will be added, not as lime water but as a milk of lime containing about 5 per cent. of lime by weight, which will be kept thoroughly stirred by motor-driven rakes and paddles. The coagulant department in the headhouse contains besides a storage room, three slaking tanks 7 ft. in diameter and 6 ft. deep, and three milk of lime tanks, 11 ft. 3 in. by 11 ft. by 11 ft. deep. Ventilating arrangements are provided to remove the steam and lime dust from the slaking room. Sulphate of iron will be prepared as solutions containing 5 per cent. by weight in three tanks, 8 ft. by 10 ft. 6 in. by 10 ft. deep. A similar set of tanks is provided for the application of soda. Compressed air will be used for stirring the solution of soda and sulphate of iron. All of the tanks in the headhouse are of concrete. Lead-lined iron pipe will be used for the sulphate of iron solutions, for the most part, several connections being of copper or brass. Iron or vitrified pipes will be used for the soda and lime.

The headhouse, 150x50 ft. and two stories above the water level, will contain in addition to the coagulant department the main office for the purification works and a suite of laboratories. The latter, four in number, occupy an area of 1,000 square ft. and will constitute an important part of the plant from the standpoint of efficient and economical operation. Beneath the main floor of the headhouse will be a chamber for the sludge pumps and numerous compartments or waterways to facilitate the flow of water to various connecting portions of the plant in a manner best suited to the varying character of river water.

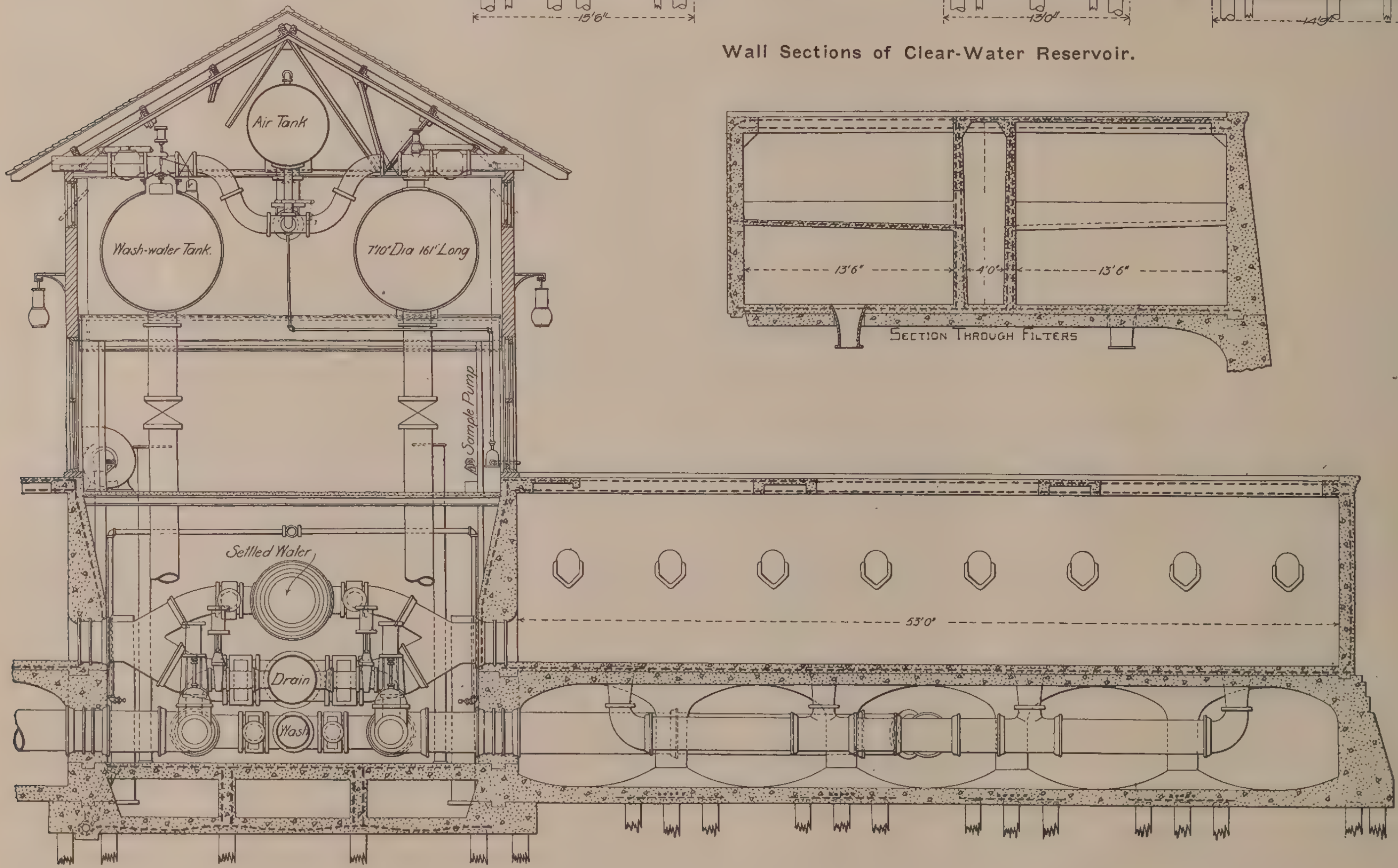
The flow through the lime-mixing passages will normally require about one hour and the velocity will be such as to facilitate the solution of the applied milk of lime, the reaction of the resulting lime water with the river water, and the thorough mixing of the resulting precipitate with the silt and clay. The water will then reach the head house again and will be passed into the coagulating reservoirs, holding about 7 hours' normal supply, where subsidence due to the coagulating effect of the lime will take place and where sulphate of iron will be added to complete the coagualtion and to eliminate the caustic alkalinity. River water will also be conducted to the coagulating reservoirs to assist in reducing caustic alkalinity, if required. These reservoirs are in several compartments so that the period of subsidence can be varied as desired. The treatment of the water in the grit, lime-mixing and coagulating reservoirs will be a continuous process, the water flowing through each compartment constantly. From the coagulating reservoirs the water will pass through the headhouse and on to the filters.



General Arrangement of Filters on Operating Floor.



Wall Sections of Clear-Water Reservoir.

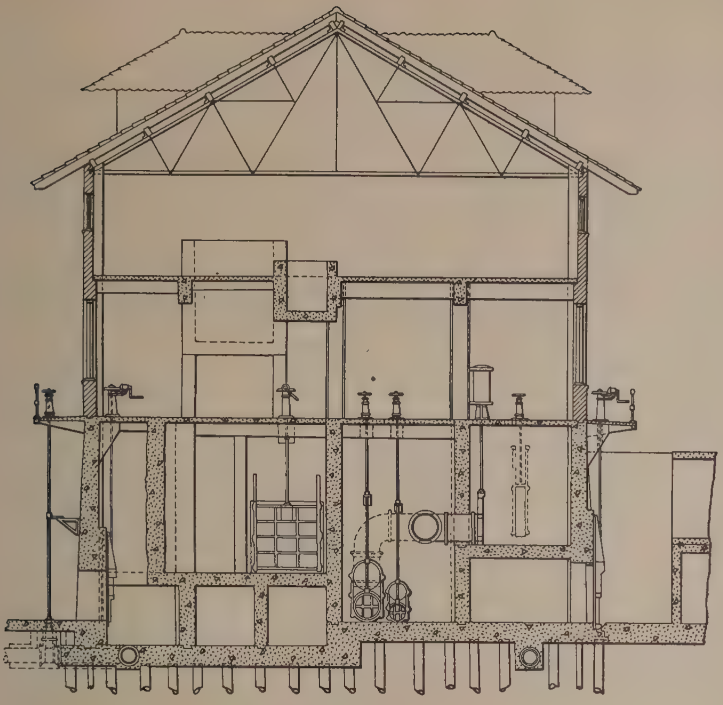


Section Showing Piping Layout in Filters and Filter Gallery Building.

The flow through the filters will be automatically regulated between fixed limits, ranging from a 50 per cent. underload to a 50 per cent. overload. The normal daily yield per filter unit of 1,430 sq. ft. will be 4,000,000 gal. corresponding to a rate of 125,000,000 gal. per acre per day, or about 2 gal. per square foot per minute. By a gradual change in rate so that their efficiency will not be affected, the filters will tend to respond to the demands of the distribution pumps, filtering at a high rate when the water level in the equalizing clear water reservoir beneath the filters is low and at a low rate when it is high. The equalizing reservoir is directly connected with the pump well, and each filter can be placed under this form of control or can be set to any required rate regardless of the height of water in the pump well.

Other than as regards their comparatively large size of unit the filters will be characterized chiefly by being uncovered and by being washed with water without the aid of agitation of the sand layers either by compressed air or by mechanical stirrers. They are designed to receive wash water at a vertical velocity of 30 in. per minute. Wash-water will be supplied from two steel tanks placed beneath the roof of the filter house, and into which water from the distribution system will be allowed to enter slowly. Above the wash-water tanks wil be a third tank, with suitable regulating valves, to receive the air forced from the wash water tanks. This air can be compressed to about 60 lb. pressure and will be available with the aid of reducing valves for increasing the rate of flow of water from the wash-water tanks to the filters as desired.

To insure a constant supply of water in the pump well, and a fairly uniform rate of filtration, the covered clear water reservoir, holding about 6 hours' supply, will be pumped full at night



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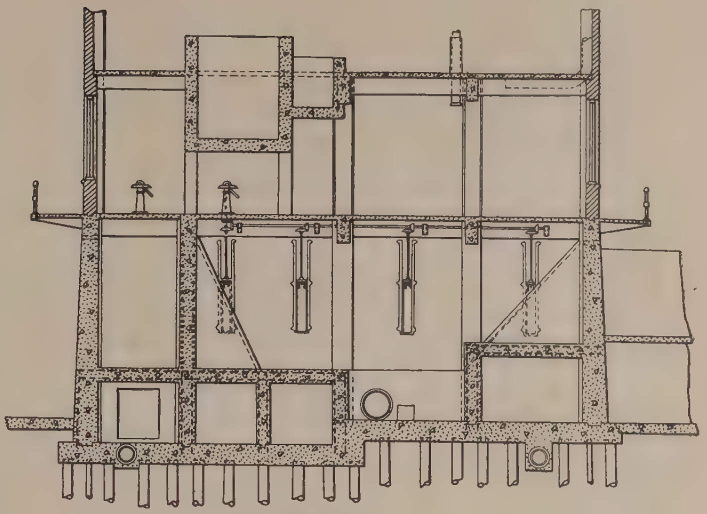

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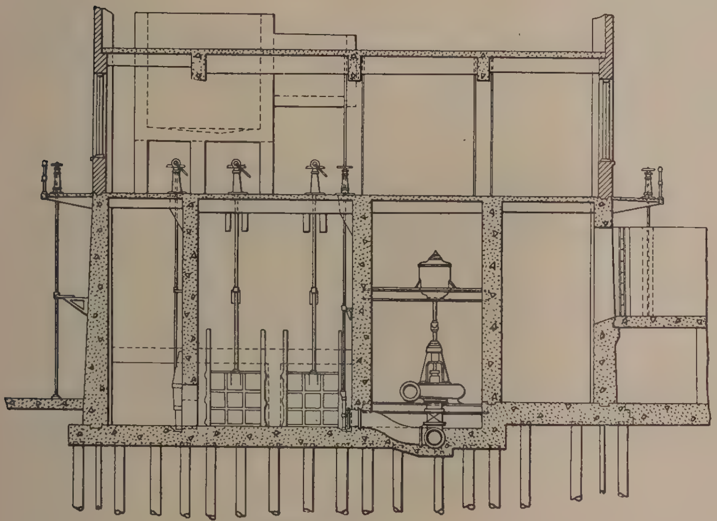

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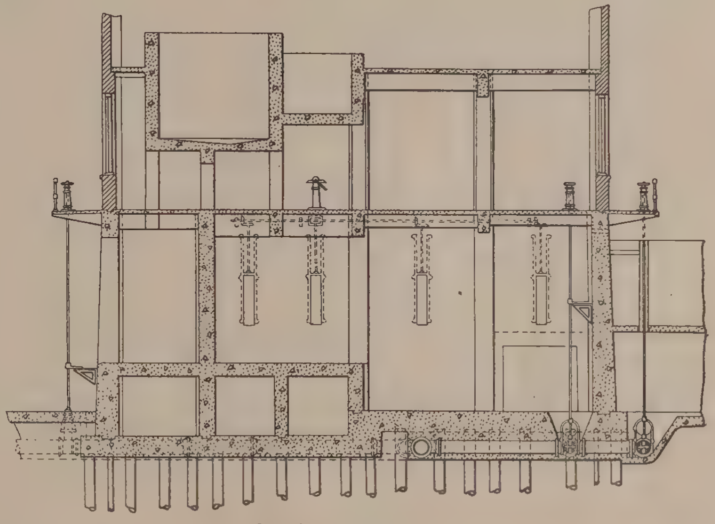

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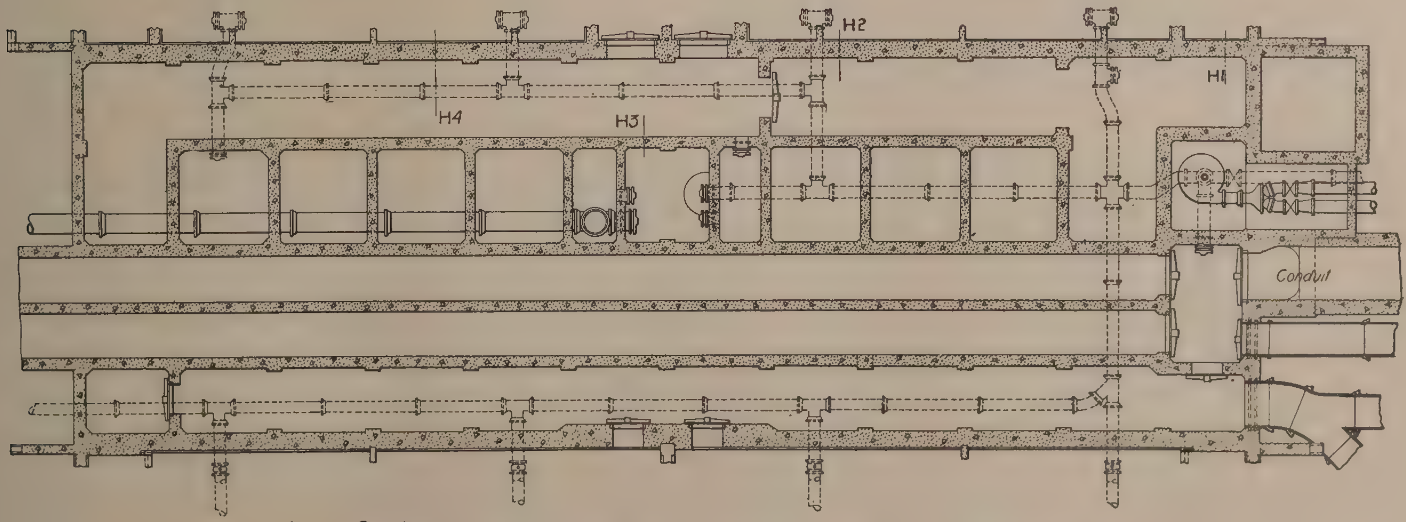


Sectional Plan of Headhouse Immediately above the Foundations.

when the consumption is low. These are connected to the pump well by a 48-in. pipe line in which is an automatic valve which will open whenever the water in the well falls below a predetermined level. The water is forced into the distribution mains by vertical triple expansion crank and fly-wheel pumping engines supplied with steam by water-tube boilers equipped with automatic stokers.

The 4,000,000-gal. plant, which in general design and operation is very much like the larger one, is situated on the west bank of the river and will serve the Algiers district with a population of about 20,000, about one-fifteenth of the city.

The construction of these works is in the hands of the Sewerage and Water Board of New Orleans, Mr. Geo. G. Earl, General Superintendent and Chief Engineer. The purification plants were designed by Mr. Geo. G. Earl, Messrs. Geo. W. Fuller and Rudolph Hering acting as consulting engineers. Messrs. Black & Laird, Ltd., New Orleans, are the contractors for the two plants, exclusive of the pumping machinery. Their bid was $1,840,727.30. The equipment of the filters was sublet to the Roberts Mfg. Co., of Philadelphia.

The Use and the Abuse of Sewage Purification Plants.

A paper read before the Ohio Engineering Society by Mr. A. Elliott Kimberly, Special Assistant Engineer, Ohio State Board of Health.

The adequate protection of inland streams and lakes from pollution by the sewage of cities and towns has become one of the great problems of the present day. From the early nineties the advance in knowledge of the art of sewage purification has been so great that to-day as a result of research and of experience gained by the operation of sewage purification plants upon a large scale, it is generally considered practicable to carry the purification of domestic sewage to such a state that the once foul liquid is rendered stable and no longer shows putrefactive tendencies. In a further discussion of the subject, which is no doubt familiar to the members of this society, the thought suggested itself to the speaker, that some benefit might accrue from viewing it from the standpoint of practical results, that is, with this question in mind: By the use of the sewage plant has there been afforded a protection of rivers and bodies of water; or if not, what are the causes underlying the failure of the sewage purification plant to accomplish this end?

Problem of Sewage Purification.—Shortly after the introduction of the water carriage system of sewerage in 1855, it began to be recognized that the withdrawal of the liquid wastes of the community from the immediate neighborhood of the city or town did not entirely effect their satisfactory disposal, especially where such communities were located on the banks of streams of small flow subject to summer drought. During such low flows, offensive odors would emanate from the sludge deposits on the drying shores, affecting the health and welfare of the inhabitants of the community itself or of others located below upon the same stream. For the benefit of the community itself, or as a result of suits on the part of the lower riparian owners, it became necessary to adopt such means for the purification of the polluting discharges that the original purity of the stream would be restored to as great an extent as practicable. Such, in a general way, is the case to-day, especially in inland cities and towns located upon the banks of small streams. A dilution of from 36 to 45 to 1, such as is usually considered to be sufficient to prevent putrefaction on the part of mixed sewage and river water, is usually obtainable only in the case of cities or towns situated on the shores of the larger rivers, hence in other cases the problem of the purification of sewage presents itself for consideration.

As it well known, the extent to which it is necessary to carry the purification of domestic sewage is governed largely by local conditions. By this is meant that according to circumstances of flow of a stream, the character of its waters and their subsequent use as a source of water supply, the needed degree of purification of the sewage discharged into the stream may vary within wide limits. Aside from the discharge of sewage into the sea, where after rough screening, putrefaction is overcome by processes of dilution, the needed degree of purification of domestic sewage may be said to be governed by three general rules. These are as follows:

1. Where the sewage effluent is to be discharged into running streams subject to floods and with a water containing considerable turbidity at all seasons of the year, the degree of purity required need not be more than that of an effluent which undiluted will no longer putrefy under summer conditions.

2. In streams the waters of which are clear except at times of flood, the purification of the sewage should be such as to remove from it the largest practicable quantity of suspended matter, so that the visible purity of the stream will not be affected, the non-putrefaction of the effluent being taken as coincident with a degree of purification which will afford an absence of all but small amounts of turbidity.

3. In drinking water streams, and in certain cases of sea discharge where shell fish layings must be protected from contamination, the purification of the sewage must needs be carried out to its fullest extent, and besides the production of a chemically stable effluent, the problem practically reduces itself to the destruction of all the disease-producing bacteria present in the raw sewage, by subjecting the well-purified effluent to some form of sterilization process.

The conditions referred to in the first instance are such as obtain quite generally in Ohio and the Middle West. In practically all of the plants in operation in this State, the attainment at all times of a non-putrescible effluent would saisfactorily accomplish the purpose for which the sewage plant was installed. That is to say, in this section of the country where the glacial drift formation is absent and where abound clayey soils subject to easy erosion, practically all streams are muddy throughout the year, and except in a few cases where there is involved the protection of a water supply, the abatement of a nuisance from the discharge of sewage into small streams with but low dilution, is readily effected by processes of purification, depending upon the use of filters of coarse material operated at fairly high rates and yielding effluents, which, when clarified by subsidiary subsidence, mixed with river water, successfully pass tests for ultimate stability.

In cases where streams are of low turbidity except in flood stages, processes of sewage purification looking merely to the ultimate stability of the effluents therefrom, owing to the suspended matters incidental to their effluents, will tend to impair the general appearance of the stream, and in these, advantage must be taken of types of purification processes involving the use of materials of fine grain and operated at comparatively low rates. Such conditions are generally found in New England and in some of the States upon the Atlantic coast line, where, fortunately, sandy areas of suitable size and character are usually available, and under proper supervision and intelligent management, the use of these areas produces effluents of a high degree of purity containing but small amounts of suspended matters for the greater part of the year.

In streams used subsequently as a source of water supply, the discharge of sewage therein must be prevented whenever possible. Many instances are to be found, however, of sewage discharge under such conditions as the above, and hence there becomes necessary a form of sewage treatment that not only will prevent what may be called the chemical pollution of the stream, but such as will destroy all bacteria of pathogenic origin as well. As yet, but little practical knowledge has been developed in this country as to the practicability of destroying the bacteria of disease which the most thorough practical sewage treatment fails to remove. Considerable recent work, however, has been done along this line in England and in the United States, and experiments have been conducted in several places in this country looking to a solution of this phase of the sewage problem. A number of disinfectants have been tried thus far, chief of which may be mentioned: Lime, acids, ozone, permanganate chlorine as bleaching powder and also produced electrolitically, and copper sulphate.

Data are yet too meagre to enable conclusions to be drawn as to the practicability of the disinfection of sewage effluents, in part as to the most efficient reagent to be employed, and in part on the grounds of cost, but with the accumulation of evidence from experiments carried out up to the present time, it appears to be quite generally recognized that the day is not far distant when drinking-water streams will be rendered free from pollution by sewage bacteria of disease origin by the use of sterilizing agents, before the sewage effluent carried to a non-putrescible state by a modern process of sewage purification, shall be allowed admission into a stream used below the outfall for domestic consumption.

Ohio Sewage Plants.—At the present time the Ohio plants comprise eighteen municipal, town or village plants and nineteen institutional plants; seven are under construction and the number of proposed plants appears steadily to increase.

The sewage plants in this State embrace practically all the principal methods of sewage treatment from simple clarification by the use of chemicals followed by settling tanks (chemical precipitation), a practice followed so largely in the earlier days of sewage treatment, to the modern continuous filter composed of particles of coarse grain and operated with settled sewages at high rates of filtration per acre. In fact, within about a year, the city of Columbus will be treating its sewage in a plant which represents the most advanced type of sewage purification plant, wherein the screened sewage, settled in septic tanks, will be applied to filters of coarse grain material 5.0 ft. in depth, the application of the sewage being effected by means of nozzles operating under a head of about 5.0 ft., causing the sewage to reach the filters in a spray or in fine drops similar in effect to the action of lawn sprinklers. The Columbus plant when completed will be the largest of its type in operation in this country, as it will comprise septic tanks of 8,000,000 gal. capacity, ten acres of filters and subsidiary settling tanks of 4,000,000 gal. capacity, the ultimate capacity of the design being 20,000,000 gal.

General Efficiency of Ohio Plants.—In view of the great variety of sewage purification treatments carried out in this State, it is not surprising that the degree of purification obtained varies within very wide limits.

The older chemical precipitation processes at best effect a clarification of the sewage with a removal of from 50 to 60 per cent. of the suspended matters, but, of course, the resulting effluents are highly putrefactive, of foul odor and require a high dilution with river water to prevent the rise of a nuisance along the shores of the streams into which they are discharged. In some instances, moreover, the effluent appears to be more highly putrescent after chemical treatment than before, due, it would appear, to the well-known solutionizing action of lime in excess upon suspended organic matters.

In general, it may be said that the treatment of sewage by chemical precipitation alone will probably be productive of foul odors and obnoxious conditions, in addition to the heavy burden of sludge disposal, and in the speaker's opinion, the process, except in rare cases, is to be considered superseded by those of more recent origin.

In the smaller plants, sewage is treated either upon areas of sandy soil, at times also heavy with clay, or upon sand filters of artificial construction, according to the well-known process of intermittent filtration. The variation in the details of a sewage plant of this type is very great, especially as to the character of the filtering medium, the method of flooding the filters, the amount of sewage applied at each dosing, and the amount of preparatory treatment to which the applied sewage has been subjected.

Excellent results are being obtained by the intermittent filtration process in cases where the material is of suitable grade, the quantity of sewage to be treated is not excessive, and where the supervision is such that the filters receive the proper amount of attention, by which is meant the raking of the surface material, the operation of the filters upon a strictly intermittent basis, in the absence of automatic flooding devices, and the thorough cleaning of the filters in case there develops evidence of ponding due to over-dosing or to clogging on the part of the surface layers.

As a general rule, the filters composed of material of fine grain now in operation in Ohio may be said successfully to purify the sewage applied to them, except in the case of a number that need enlargement or to which but little attention has been paid on the part of those in charge. The clear-cut effluent obtained from the intermittent sand filter is met with occasionally, but requires optimum conditions with respect to the quantity and the quality of the applied sewage, rigid intermittence in the flooding and careful attention to the filter surfaces to ensure the ready admission of the oxygen essential to a maximum of oxidation.

In a number of plants constructed in the last eight years, some form of preparatory treatment has been included in the design aside from the older chemical precipitation processes. Chief of these processes is the treatment of the crude sewage by sedimentation in septic tanks, wherein there is effected a removal of about 50 per cent. of the suspended matter of the crude sewage with the resulting liquifaction of from 25 to 50 per cent. of the deposited sludge. At the present time there are fifteen septic tanks in operation in this state; of this number, twelve are covered and three are open tanks.

The general appearance of the different septic tanks varies greatly. Of those mentioned above, some appear to destroy sludge readily, while in others the accumulation of sludge is quite rapid. The presence or absence of scum on a septic tank is somewhat difficult to foretell, as it seems to be dependent upon several conditions, chief of which perhaps is the relative strength of the sewage, dependent on the per capita sewage flow. With a small per capita flow, sewage tends to possess a turbid, milky appearance, is strong smelling after but short storage and contains a relatively large proportion of colloidal suspended matters. Highly diluted sewage, especially where large amounts of surface water are included, generally carries suspended matters of a flocculent character, capable of rapid subsidence under a reduced velocity and at times carries a small amount of dissolved oxygen through the septic tank. Broadly speaking, sewages may be separated into the above two classes, the division between which is rather indefinite. From the observation and the experience of the speaker, however, it has been noted in many instances that scum formation and highly concentrated sewage are in some way intimately related, as in the case of tanks treating weak sewages, the rising sludge forced upward by the gases incidental to sludge fermentation generally falls back again before a permanent scum has an opportunity to be formed.

The efficiency of the septic tank may now be said to be dependent upon the relative quantity of suspended matters that may be removed by the tank, the older view of the modification of the liquid portion of the sewage itself having been disproved by a number of instances in recent years. Without the aid of chemical analysis and carefully averaged samples extending over a considerable period, it is of course difficult to judge of the actual efficiency of the septic tank. At the same time, from the general appearance of the oxidizing devices and from the fact of the successful operation of the plant at rates considerably higher than would be possible were the raw sewage applied to the filters, it will be apparent that the septic tank as a preparatory process for the removal of a part of the suspended matters in many instances has proven itself an important factor in sewage purification.

There is another side of the treatment of sewage in septic tanks that deserves considerable attention, namely, the disposal of the residue from the hydrolysis of the sludge. The first advocates of the septic process were firm in their convictions that at last there had been devised a process for sewage treatment that would effectually solve the problem of the sewage problem, the disposal of the sludge. Many statements were made and many views were expressed that a septic tank, when installed, would never require cleaning; that in some manner not clearly understood it was capable of destroying the sewage solids to be subsequently applied to it. Such views are now known to be untenable. While the process does effect the destruction of a certain proportion of the deposited suspended matters, yet there always remains an ever-accumulating quantity of sludge which in course of time requires removal, in fact in the most modern designs sludge areas are provided for the cleaning of the tanks.

Considerable experience has been gained relative to the cleaning of septic tanks, and the undertaking is not generally considered to be attended with the production of a nuisance, as might be supposed. In fact the removal of the sludge from a septic tank which has been in service for a considerable period, may readily be handled at any plant without particular discomfort on the part of the workmen or of the people in the immediate neighborhood. The absence of odor in well-matured septic sludge is such as to cause considerable comment when for the first time an opportunity is afforded to witness the cleaning of a septic tank. As reported by Mr. R. W. Pratt, C. E., the Mansfield septic tanks were cleaned in the spring of 1906. In all there was removed about 1,200 cu. yd. of sludge. This sludge was of a pasty nature, it had been compacted during its four years' storage to a water content of only 82 per cent., and, further, its putrescent components had been so altered by bacterial decomposition that the wind blowing over a comparatively large surface of the sludge ponded to a depth of a foot and freshly deposited, brought therefrom practically no noteworthy odors. Such then is the result of what may be said to be one of the important offices of the septic tank, the conversion of the non-hydrolized sludge into a residuum no longer amenable to putrefaction and without an appreciable odor.

In addition to the above mentioned points in regard to the efficiency of septic tanks, there is still another phase of this form of preparatory treatment which deserves more than a passing notice, that is, the periodic upheaval of the sludge deposits and the consequent clogging of the oxidizing units by the suspended matters thus carried onto the surface material. It is a well-known fact that there are periods in the operation of a septic tank usually subject to continuous quiet ebullition of gases, and with a relatively high subsidence efficiency, when of a sudden there rises to the surface of the sewage large masses of undigested suspended matters borne upward by the sudden release of a comparatively large quantity of gas confined under perhaps a heavy deposit of sludge. At such times, the suspended matters in the effluent increase abnormally and tend to choke the pores of the filters, and in certain cases cause the production of decided odors in and about the tank and the plant. This feature of the periodic upheavals in septic tanks, in many ways is, of course, a marked detriment to the process, owing to the load of finely divided suspended matters that are forced upon the oxidizing devices; it is, however, a condition which may be considered as inevitable in the case of most sewages and to a certain degree it would be desirable to provide means to prevent the damage which is caused by the sudden discharge of suspended matters in such large quantities. Generally, aside from surface baffles located near the outlet end of the tank, these being intended to cause the sewage in discharging to pass out with a minimum of disturbance, no special devices have been employed to reduce the suspended matters at the periods of unusually violent septic activity, and the effluent heavily charged with suspended matters passes on to the filters. At such periods filters of fine grain require especial care in their operation, and unfortunately for the general efficiency of the plants, the lack of attention they receive is in many cases deplorable. In the case of strong sewages it appears to be a difficult matter to control these fomenting periods in septic tanks, although tanks on the comparment plan and those operated in series may quite possibly be effective in some instances.

About the time sudden impetus was given to the construction of sewage plants by the rise in favor of the septic tank as a part of the design of such plants, considerable work was carried out particularly in England as to the feasibility of treating sewage in filters composed of fairly coarse grain material. The first of these were operated upon the contact plan, wherein the outlet of the filter is closed, sewage admitted until the pores of the filter are filled, after which the sewage is allowed to stand for a stated period in contact with the filtering material, thus subjecting it to the action of the bacteria retained thereon. The contact filter will be recalled as a type of filter resulting from the increased knowledge of the bacteriology of sewage treatment brought forward particularly as, by its adoption, the purification of sewage was hoped to be the more economically accomplished in cases where fine grain material was scarce and where a limited area was available as a site for the sewage plant. As the head required for the operation of a sewage plant involving contact filters is less than that necessary for the most recent development—the sprinkling filter—there are many cases where the installation of a contact filter plant may successfully solve the problem of sewage purification especially where sand filtration is impracticable.

The plants operated on the contact priniple in Ohio number eight, and in each case the sewage is subjected to some form of preparatory treatment before being oxidized in the filters. The efficiency of these plants varies considerably. In some instances the resulting effluents are carried to the non-putrescible stage as a result of the preparatory and the oxidizing treatment, while in others, the effluents of the contact filters possess considerable odor, are free from dissolved oxygen and protecting nitrates, and do not successfully pass tests for putrescibility.

In the majority of cases the effluents as discharged are low in suspended matters and hence of good apeparance. This feature of the retention of the suspended matters of the applied sewage is characteristic of the contact filter and it is evident that the amount of suspended matter contained in the sewage applied to filters of this type controls in a measure their holding capacity and thus the period between obligatory cleanings of the filtering material. Owing to the detrimental effect caused by flooding contact filters with a poorly prepared sewage, that is, an influent of high suspended matter content, the operation of contact filters in conjunction with septic tanks should be carefully watched. By taking advantage of the flexibility of the design of the preparatory devices, the endeavor should be so to operate them, that, changing conditions being met by modified operating procedures, the sewage applied to the contact filters may be as free as possible from suspended matter, never showing evidences of too prolonged retention, conditions which will tend to enable the contact filters to operate at their best with a minimum of clogging.

While the sandy area or the artificial sand filter receiving practically crude sewage or that treated by subsidence in septic tanks, are chiefly represented among Ohio plants, yet there are certain cases where a finishing process follows the oxidizing treatment, by which are obtained effluents of considerably purity, generally stable and of low suspended matter content.

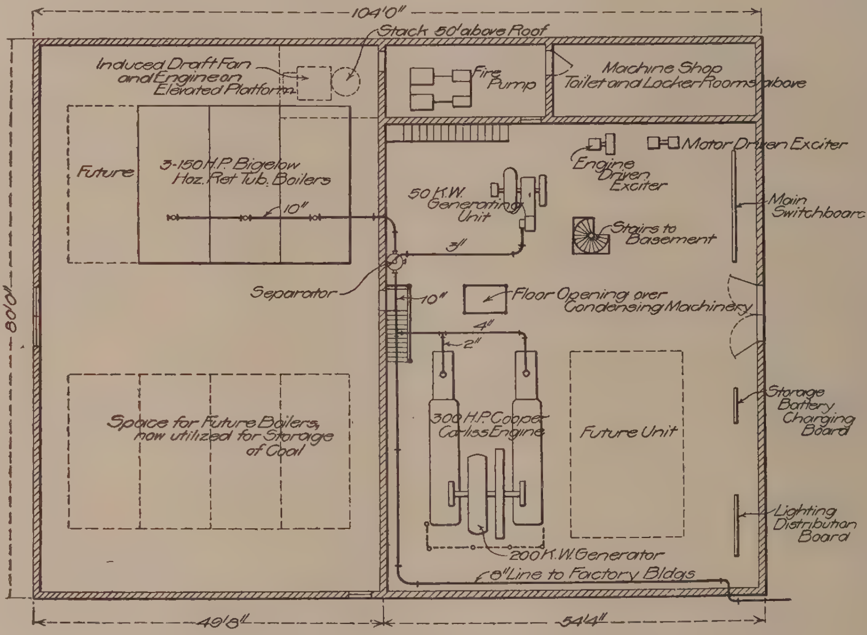
Neglect of Sewage Plants.—The failure of the sewage plants at present in operation, is due in many instances to the lack of careful supervision, to the utter disregard of the principles underlying the successful prevention of a nuisance by the use of the sewage plant, to exceeded capacity and at times to faulty design. The types of sewage plants represented by those just reviewed, depend for their success upon the manner in which they are operated.

The idea that the construction of a sewage plant ends the matter in so far as relates to those responsible for its construction, is clearly false in the extreme. New conditions are constantly arising brought about, if you will, by the ever-increasing volume and strength of the sewage due to new connections, especially in towns recently sewered, and to meet such changed and ever-changing conditions means should be provided for the due care and attention of the sewage plant at all times. In planning the purification of the sewage of a city or town questions of economy at times demand that the areas initially provided shall be limited to such as will effectively handle the estimated sewage flow for the immediate needs of the community, together with slight additional amounts to provide for future growth. In addition to the quantity of sewage provided for by the design, the flexibility of the design should be such that additions to the plant may readily be made when the future demands upon the plant require such extensions. As the period of service of the sewage plant increases and as the adoption of the water carriage system of sewage becomes more general in a community, the sewage plant in many instances subject to but scant attention has become so overburdened by the largely increased volume of sewage reaching it daily, that under the best of supervision and management it will not be adequate to meet the increased volume of sewage flow. There appears to be but little attention paid to this side of the sewage purification question and as a result there are to be noted a number of plants which are fast approaching the nuisance stage. The needed increase in the area of a sewage plant commensurate with the increased number of connections with the sewage system brings up the further point that before drawing definite conclusions as to the problem of the sewerage of a city or town, in cases where disposal by dilution may serve for a time to prevent nuisance, the details of the sewerage system should be such that a sewage purification plant may be installed without undue cost when dilution facilities become inadequate with the increased use of the sewers.

With the installation of an automatic device, the idea seems to have become fixed in the minds of some, that such devices eliminate for all time the necessity for all supervision and at times plants so equipped are to be found in a state of sad neglect. Not alone do the filters themselves suffer from this lack of care and attention, but the dosing or discharging apparatus itself has gradually deteriorated, its moving parts have become rusty for want of oil with a final result that the feature of automatic operation has to be abandoned and the plant is then hand operated with enforced supervision, often times but little more systematic than obtained during the life of the automatic appliances.

In the case of plants operated on the intermittent basis, it is apparent that considerable care is necessary to keep the surface material porous and free from vegetation, in this way overcoming the deterioration of the effluent resulting from the inability to operate the filters intermittently. The cost of maintenance for sewage plants is not as great as might first appear and surely by due regard to the condition of the plant at comparatively frequent intervals, thereby insuring its high efficiency at all times, there will be entailed less cost in the long run than the extensive repairs, weed cutting, grubbing, plowing, etc., eventually necessary when plants have been utterly neglected for long periods.

For the protection of the waters of this ever-growing country there is a need for the purification of all sewage within a given water shed. With a sewage plant ready for service, every effort should be made to operate it to the best advantage. Unless the results obtained from sewage plants under practical operation are such as to be considered reliable indications of the merits of a given design, future progress in the art of sewage purification has apparently received a serious setback. It may not be too strong a statement to make that the weak side of the present status of sewage purification is the fact that after the plant is designed its efficient operation is so rarely assured that no opportunity is afforded the engineer to follow up his work, to study the efficiency of his design upon a practical scale and to add to the progress of the art of sewage purification by the modification of future designs according to the experience gained from the operation of plants designed according to older standards. A neglected sewage plant can hardly be counted upon to afford much reliable information along the above mentioned lines, hence it is apparent how urgently necessary is a radical improvement in the handling of sewage purification plants.


104'0"
Stack 50' above Roof
Induced Draft Fan and Engine on Elevated Platform
Fire Pump
Machine Shop Toilet and Locker Rooms above
Motor Driven Exciter
Engine Driven Exciter
Future
3-150 H.P. Bigelow Hoz. Ret. Tub. Boilers
10"
50 K.W. Generating Unit
3"
Main Switchboard
Stairs to Basement
Separator
10"
Floor Opening over Condensing Machinery
4"
2"
80'0"
Space for Future Boilers, now utilized for Storage of Coal
300 H.P. Cooper Corliss Engine
Future Unit
Storage Battery Charging Board
Lighting Distribution Board
200 K.W. Generator
8" Line to Factory Bldgs.
49'8"
54'4"

Plan of Power Plant of the Works of James Pyle & Sons.

The need for the expert supervision of the sewage plant, especially in the early history of its service, is well expressed by Alvord in a paper read before the Western Society of Engineers, several years ago. He says: "The termination of the expert supervision of sewage purification plants usually takes place a few weeks after their completion. The engineer who had their inception and formation, and who has studied every phase of their environment, who knows what kind of sewage is to be dealt with and its quantity and variations, who understands how such variations are to be met, and who will be equal to any emergencies, drops out, is paid off, and the plant is turned over to the tender mercies of a place-hunter perhaps, or is forced on the unwilling care of some city official with other duties which already fill his time. This is wrong, and to this condition can be traced many cases of dissatisfaction on all sides. The engineer who has carefully designed and constructed a sewage disposal plant should be retained to supervise its operation for at least a year after it is started. He is the one of all others who can successfully launch it on a successful career, and meet the problems of control."

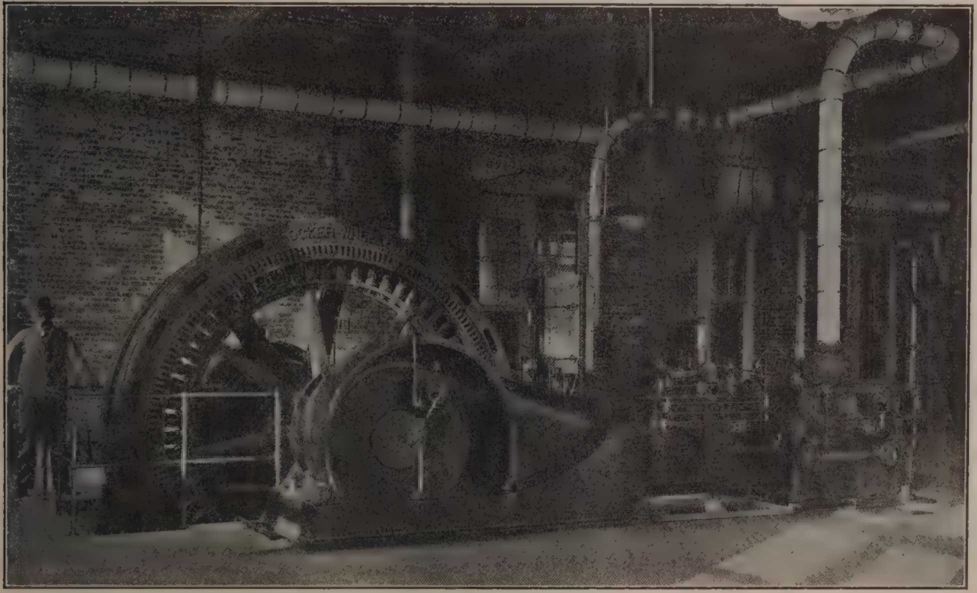
Another phase of the neglect of the sewage plant is the indifference exhibited by officials. The sewage plant is not a revenue producer, it was installed in many cases as a result of suit, it will probably reflect no special credit on the political administration, hence a tendency to cut to a minimum charges for operating expenses, to allow it to pass into oblivion. As the sewage plant represents so much of the city's invested capital, why is it not to be considered as such, and dealt with accordingly? For an equal investment in a private enterprise, not only would care and attention be paid to its management, not only would systematic daily records be kept of the features of its operation, but there would also be provided a sinking fund for its subsequent renewal. How different are the facts in the case of many of the sewage plants. Such instances serve to show the necessity for a strong effort to improve present conditions, and all in any way associated with sewage purification plants should take advantage of every opportunity to place the practical side of the purification of sewage on a better footing.

In these days of the rapid advance of sanitary science, it is signally fortunate that by recent Ohio legislation there has been provided a means whereby attention may be called to the neglected sewage plant and whereby opportunities may be afforded for closer study of the sewage problem upon a practical basis, with the endeavor to raise the operating standards of all sewage plants that they may effectively solve the problems of sewage purification.

Peat Briquettes are now being made at Norfolk, Mass., with a machine invented by Mr. M. C. Sharpneck, and controlled by Dr. S. D. Treible, of 41 Boylston St., Boston. The peat is cut up by revolving knives like a meat chopper and then pressed through a die in a continuous bar, which is sliced into briquettes by a knife operated automatically.

Power Plant of the New Works of James Pyle & Sons.

An extensive plant has recently been completed for James Pyle & Sons, at Shadyside, N. J., for the manufacture of Pearline powder and other soap products. The location of the works is at the foot of the Palisades on the west shore of the Hudson River, some six miles north of Jersey City and directly opposite 90th St., Manhattan. Ample space available at this site permitted an arrangement of plant best suited to the handling of materials and processes of manufacture, and a scattered lay-out of buildings was selected with power transmission for its operation from a central power plant. There are two large manufacturing buildings, one three stories and the other five stories in height, and a two-story stock and office building. The former are of fireproof construction throughout, while the latter is of modified mill construction. The power requirements of the plant include the supply of steam for heating the buildings and for the operation of boiling tanks for the manufacturing processes, and also the supply of power for the operation of machinery and lighting. The power plant is located at the rear of the site, convenient to rail connections for the receipt of coal.



Cooper Corliss Engine and 185-Kw. Generator.

The station is a brick structure nearly square in shape with concrete floors and wooden roof carried on steel trusses, and is divided through the middle by a brick wall separating the boiler rooms from the engine and pump rooms. The boiler room is 50x80 ft. in size, having its floor practically on ground level, with a clear headroom under roof trusses of 20 ft. The engine room is 54x68 ft. in size with 15 ft. headroom under roof trusses and its floor elevated for an 8-ft. basement underneath. The remaining 12 ft. space at the north end of the engine room is a pump room and a workshop at the boiler room floor level, and above these a laboratory and locker room. A feature of the design is the simplicity of building construction and layout, which provides for very considerable extension in capacity without alteration of the present structure. In the boiler room there are at present but three boilers, although the projected arrangement provides for another unit to the present row at the east side and subsequently four more on the opposite side of the firing floor in the space which is now utilized for the storage of fuel. In the engine room there is sufficient space for the addition of another large generating unit alongside the present one, while additional smaller units may be located in the northerly section of the room.

There are three Bigelow horizontal return tubular boilers, each of which has a heating surface equivalent to a rating of 150 h.-p. The shells are 72 in. in diameter by 18 ft. in length, without domes, and contain 72 4-in. tubes, 18 ft. long. The settings are fitted with U. S. shaking grates for hand firing, a fine grade of anthracite fuel being used. In preference to a tall stack for natural draft, an induced draft equipment has been installed consisting of a Sturtevant fan located on a platform above the boiler settings at the rear and discharging through a 48-in. steel stack which extends about 50 ft. above the power house roof. The fan has an overhung wheel to remove the bearings from the heat and is driven by a direct-connected Sturtevant enclosed engine. No coal or ash handling equipment has been installed, coal being stored in a pile at the rear of the boiler house and also in a vacant portion of the boiler room, from which it is wheeled to the firing floor. Ashes are at present utilized for filling in low portions of the property.

The steam piping has been laid out with special reference to future extension of the plant. There are two boiler room headers which lead to a separator at a central point in the engine room, from which the engine supplies and the high-pressure line to the manufacturing buildings are taken off. Only one of the boiler room headers is now installed, a blank opening being provided on the separator for connection to the future header on the other side. The boiler room header is a 10-in. line from which 6-in. branches connect to each of the three boilers. In the engine room there is a 10-in. connection from the separator which feeds an 8-in. high-pressure line extending to the manufacturing buildings and a 4-in. line to the compound Corliss engine which drives the large generator, this branch having a 2-in. by-pass connection to the low-pressure cylinder. From the opposite side of the separator a 3-in. branch is extended to supply a 75-kw. generating unit and also a 3-in. main to the boiler-room basement for the supply of pumps and the exciter engine at the rear of the engine-room floor.

The engine-room equipment consists of a 300-h.-p. cross compound Corliss engine direct-connected to a 185-kw. alternating current generator, a 100 h.-p. engine driving a 75-kw. generator and two exciter units, one steam-driven and the other electrically-driven. The cross compound engine is a 13 and 26x36-in. horizontal Corliss engine, built by the C. & G. Cooper Co., Mount Vernon, Ohio. It operates at a 120 r. p. m., and with a normal boiler pressure of 150 lb. and operating condensing, it has a rating of 300 h.-p. The condensing equipment, which has been installed for the operation of this engine, is of the surface type and is located in the basement between the cylinder foundations, and an opening in the floor at the rear of the cylinders facilitates inspection of the pumps and connections by the operating engineer from the main engine-room floor. Circulating water is obtained from the adjoining river through an intake line about 500 ft. in length. The smaller unit consists of a Harrisburg simple horizontal high-speed engine direct-connected to the 75-kw. generator, which, operating at 277 r. p. m. with a boiler pressure of 150 lb., non-condensing, has a rating of 100 h.-p. The exhaust steam from this engine as well as from such auxiliary machinery as may be in operation is utilized in a Cochrane open feedwater heater in the basement for the preheating of the boiler feed water. The remaining unit in the engine-room is the 30-kw. exciter which is direct driven by a New Britain simple vertical high-speed engine. Another steam-using unit is a standard underwriter's fire pump, located in the pump room enclosure adjoining the north side of the engine-room, and connected to pressure mains that lead throughout the buildings for protection of the plant from fire.

The electrical equipment consists of the 185-kw. alternator direct-connected to the cross-compound engine and the 75-kw. alternator direct-connected to the simple engine, auxiliary to which are two exciter units, one of 18-kw. capacity direct-connected to the New Britian steam engine and the other of 15 kw. capacity direct-driven by a 25 h.-p. General Electric induction motor. Both main generators are of the new alternating current type built by the Crocker-Wheeler Co., and the exciters were also supplied by that company. The generators deliver three-phase alternating current at 60 cycles and 240 volts, the large unit having 60 poles and operating at 120 r. p. m., while the 75 kw. unit has 26 poles and operates at 277 r. p. m. The exciters deliver 125 volts direct current. For the control of the generator and distribution circuits, three switchboards have been installed, one of four panels, 16 ft. in length, for the control of the two main generators, the exciters and the main feeders to the distribution board; a three-panel board 9 ft. in length on which the power and lighting distribution circuits to the different portions of the plant are controlled, and the third, a single panel board, 5 ft. in length, through which the charging circuits of an electric automobile truck that is operated about the plant are handled.

The engineer for James S. Pyle & Sons is Mr. R. S. Woodward, Jr., and the contractor for the installation of the plant was the New York Steam Fitting Co., New York.

GROUTING MINE SHAFTS in water-bearing strata has been quite successful in work described by the "Genie Civil," Paris. The quantity of cement for each injection varied widely according to the inclination of the strata, and when these approached the vertical not only was the quantity of cement required excessive but the success of the operation was by no means so pronounced. When the strata are thus steeply inclined greater efficiency has been obtained by sinking the shaft by short lengths and injecting each new length in advance by means of radial boreholes driven from the last completed length of shaft. The greatest care is necessary to prevent the fine mud from mixing with the grout.

Electrical Machinery Used in Coke Operations.

The total annual capacity for the production of pig iron by the U. S. Steel Corporation at the present time is about 25,000,000 tons. This enormous production makes the company a correspondingly large consumer of coke for use in its furnaces. With the exception of a comparatively small percentage all the coke which is used is supplied by its subsidiary companies. The two principal operators furnishing this coke are known as the H. C. Frick Coke Co. and the U. S. Coal & Coke Co. The mines and works of the former are located in the Connellsville district, largely comprising Fayette and Westmoreland Counties, Pa. Those of the U. S. Coal & Coke Co. are located at Gary, McDowell Co., W. Va. Both of these companies are operated along the same general lines. The H. C. Frick Coke Co. at present owns about seventy separate coal mines, each mine having its own set of ovens which it supplies with coal. The number of ovens at each mine ranges from approximately 100 to 800, depending upon the output of the mine and other conditions. These are located close to the openings of the mines and conveniently arranged in relation to railroad sidings. The coke ovens are, with few exceptions, of the beehive type, into which the coal is introduced at the top. The residual heat and that of the adjoining ovens starts the coking process, in which the volatile portion of the coal is driven off through the top of the oven into the atmosphere. When all of the volatile matter is driven off, the bed of coke is raked out at the bottom and loaded into cars for shipment.

The continued increase in furnace capacity of the Steel Corporation calls for a corresponding increase in coke production. It is estimated that the new furnaces under construction will add at least 2,000,000 tons to the present productive capacity of pig iron. This will necessitate between 6,000 and 7,000 more coke ovens with the necessary additional mining capacity and machinery equipment. Similar conditions prevail in respect to independent furnaces.

In coal mining power is used for operating haulage locomotives inside the mines, pumps which drain the mines and large ventilating fans. In shaft and slope mines power is also required for hoisting purposes. From the mine the coal is carried to a tipple, whence it is discharged into what are known as coke oven larries, small steel cars equipped with electric motors for propulsion and supplied with chutes for discharging the coal into the ovens. It is customary to arrange the ovens on either side of the track on which the larry runs; coal being discharged from both sides. The electric motors on the larries are small railway type machines. Electrically operated drawing machines are used for removing the coke from the ovens. The machine draws the coke out of the oven by a scraper, discharging it on a conveying belt whence it is dumped directly into freight cars. Two motors are used on this machine; one is of the series wound railway type and the other a shunt wound constant speed motor.

The operations of the H. C. Frick Coke Co. at their Yorkrun plant are of special interest on account of modern features. Of the ovens here 100 are especially selected and so connected by flues as to conduct the hot gases from the ovens to the boiler house. The heat discharged from the coke ovens represents an enormous waste, and its use under the boilers therefore saves the use of a corresponding quantity of coal to produce the same heat; thus a large amount of heat is economically obtained at Yorkrun. It is roughly estimated that the heat developed by each oven is the equivalent continuously of 18 h.p.

The powerhouse is supplied with four alternating-current generators rated 400 kw., 2,300 volt 3-phase, 25 cycles, built by Allis-Chalmers Co. The equipment is complete with motor and engine driven exciters. In the main powerhouse is located a rotary converter sub-station supplied with two 200-kw. rotary converters and six 75-kw. step-down transformers. All the machinery in the powerhouse is controlled by a large 17 panel blue Vermont marble switchboard with complement of oil switches, indicating and recording meters. The rotary converters supply direct current at 600 volts for haulage locomotives and coke oven larries at the Yorkrun mine. Alternating current is used for pumps, mine fans, hoists and scrapers. Within a radius of between two and three miles there are located at various points four additional rotary converter sub-stations; each is equipped with one 200-kw. rotary converter, three 75-kw. step-down transformers and complete switchboard. These sub-stations are located so as to supply both alternating and direct current for mining and coking operations required by one or more mines. The switchboard in the main station is provided with feeder panels for the sub-station feeder lines. By means of integrating and recording meters a record of the power consumption is afforded at each mining and coking operation.

Additional mining and coking operations can be supplied from this same powerhouse by running additional high tension lines. Instances arise, however, where this is not practicable. Where locations are too remote, or when intervening property cannot be traversed by high tension lines, it becomes necessary to install separate isolated plants. A number of such plants are now being installed to meet the increased demand for coke. At the Phillips mines two 100-kw. direct-current railway type generators with switchboards are being installed; also at Ronco mines two 200-kw. direct-current engine type railway generators with switchboard are being started and at Dearth mines two 200-kw. direct-current engine type generators with switchboard. All of this electrical equipment is being supplied by the Allis-Chalmers Co.

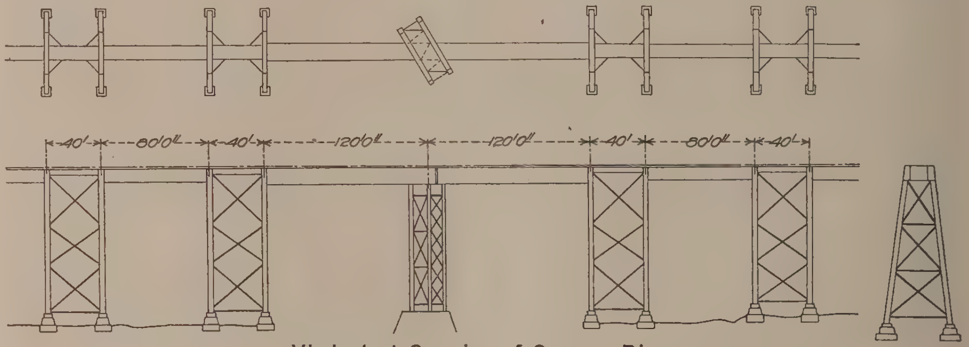
The powerhouse of the U. S. Coal & Coke Co. at Gary, W. Va., is equipped with two 24 and 42x42-in. cross compound heavy duty Allis-Chalmers Corliss engines driving 750-kw. 6,600 volt generators. In sub-stations there is a total of twenty-seven 75-kw. Allis-Chalmers transformers used for rotary converters. The general lay-out of this plant is similar to that of the H. C. Frick Coke Co. at Yorkrun except that waste heat from the ovens is not used.

A Third Pipe Line has been begun on the Thirlmere aqueduct bringing water to Manchester, England, thus completing the project as originally planned by Messrs. Hill & Sons. The water of Thirlmere Lake must be raised 50 ft. above its natural level, or 15 ft. higher than it is now, in order to supply all three pipes.

The Genesee River Viaduct, Erie R. R.

The Genesee River R. R., about 33 miles long, from Cuba, N. Y., to Hunts, N. Y., is a branch of the Erie R. R. system, which is now under construction, as described at considerable length in this journal on March 2. It crosses the Genesee River and valley on a viaduct with a steel plate girder superstructure, 3,121 ft. long and about 120 ft. in height from the water level to the base of rail. It is made of alternating 40 and 80-ft. plate girder spans, except immediately at the river crossing, and is intended to carry a single track at first and afterwards to be widened to a double-track structure. The towers are designed for the latter service, excepting that the columns will then be reinforced and the longitudinal girders are so arranged that the two lines at first erected will later serve for the inside girders of two parallel tracks. The general features of the design and the regular spans and connections are like those of the Moodna Creek Viaduct, illustrated in the Engineering Record of July 6, 1907.

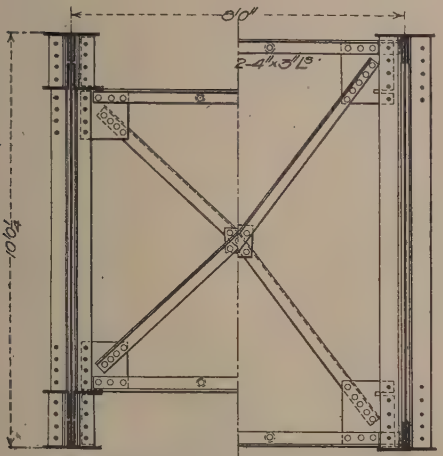
The principal difference between the two structures lies in the crossing of the Genesee River, which is made with two 120-ft. (nominal) plate girder spans supported at their adjacent ends on a 10x28-ft. 3½-in. vertical tower 120 ft. high with their piers skewed to the axis of the bridge and the direction of the river. The girders of one span have expansion bearings and those of the other span have fixed bearings on this tower, while the opposite ends of both spans have fixed connections to the regular towers. The span has square ends on both sides of the river and oblique ends on the skew center pier.



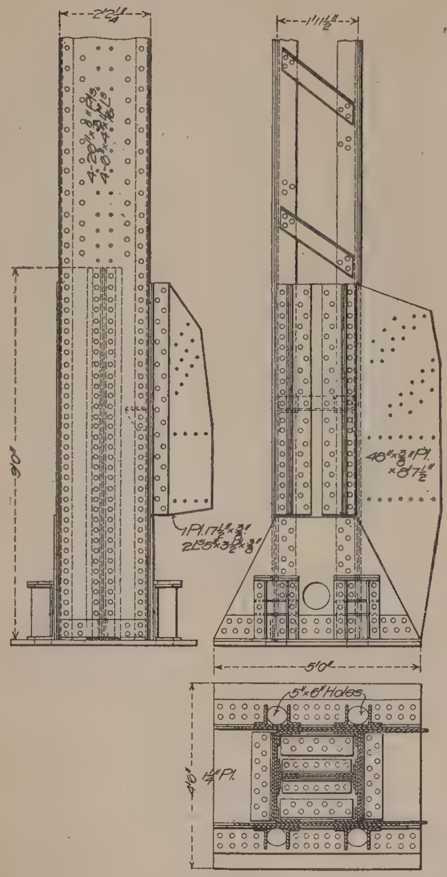
Viaduct at Crossing of Genesee River.

The columns of the river tower correspond with those in the other bents except that they are vertical instead of battered and that they are field riveted to the full-length webs of the transverse girders which is also field riveted to the top flanges of wide solid web knee-brace shop riveted to the columns. Each column is made in two sections and the lower section 65 ft. 3½ in. long is provided with a 54x60-in. base plate 1½ in. thick, stiffened by wide connection angles and four pairs of vertical pocket angles 22 in. long milled at both ends and engaging upper horizontal shelf angles to afford bearings for the nuts on the top of the anchor bolts which pass through the pockets and through the 5x6-in. slotted holes in the base plates. The column webs are stiffened at the lower end by a 22x½-in. x 9-ft. diaphragm faced to bear at the lower ends on the base plate. This diaphragm is in the plane of the one designed for the future reinforcement of the columns when the second track is added to the viaduct, and stiffens the posts for the distribution of stresses from the struts.

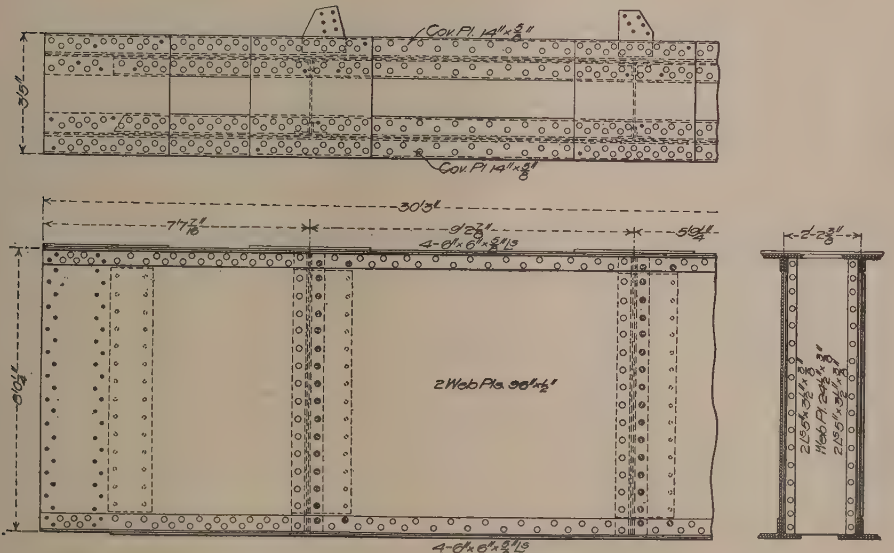
There are two transverse girders at the top of the tower carrying the longitudinal girders, each of them having two full-length 96x½-in. web plates 30 ft. 3 in. long and 26⅜in. apart in the clear. The upper ends of the columns engage these webs and are field riveted between them with one hundred ⅞-in. rivets driven in holes reamed to a cast-iron template for each column. The girder webs are connected by three ⅜-in. full-depth diaphragm plates and by four top flange tie plates. The webs in reality belong to separate girders, each of the four flanges being composed of two 6x6x⅝-in. flange angles and one full-length 14x⅝-in. cover plate. The inside bottom flange angles are cut to clear the columns.



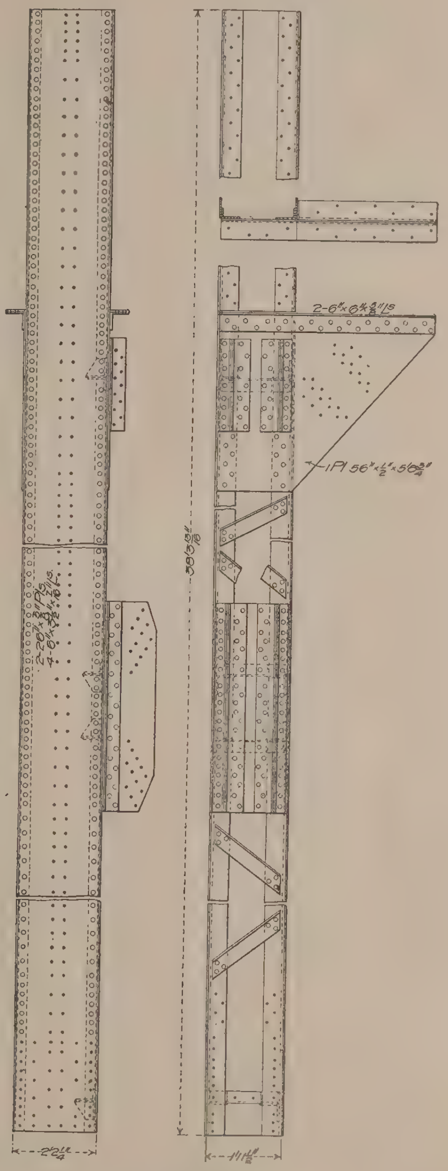
Cross Section of 120-Foot Span.



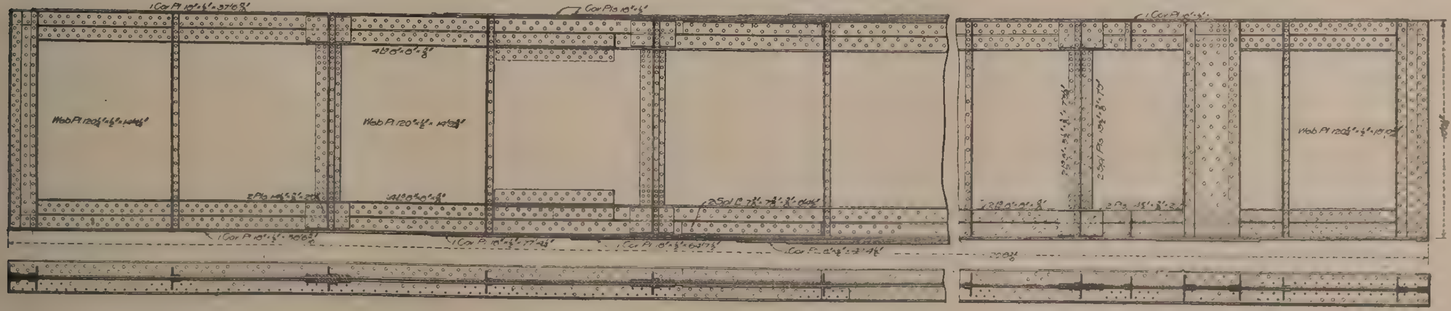
Base of Columns.



Transverse Tower Girder.



Top of Column.



Girder Over River Crossing.

The longitudinal girders of the 120-ft. spans are made with 120x½-in. web plates, in lengths of about 15 or 16 ft., spliced with four vertical rows of shop driven rivets in pairs of 13½x⅜-in. cover plates, 7 ft. 3 in. long. The top and bottom flanges are alike, each having an H-shaped cross-section made with four 8x8x⅝-in. angles and five 18x½-in. cover plates. The angles are each made in two pieces, from about 23½ to 86 ft. long with staggered splices. The outside flange angles are spliced with pairs of 7⅜x7⅜-in. cover angles 6 ft. 4½ in. long cut down from 8x8x⅝-in. angles. The inside angles are spliced with similar cover angles and have in addition an 8x8x⅝-in. angle of the same length with its horizontal flange riveted to the horizontal flange of the main angle and its vertical flange riveted to the girder web above it. The first flange cover plate is of full length and is made in two pieces spliced by the outer plates which diminish in length to 35 ft. for the last one. The web splices are carried over the vertical legs of the flange angles with pairs of short cover plates with eight shop driven rivets in each end. The web is divided into panels 6 to 8 ft. long by pairs of vertical web stiffener angles at splices and at intermediate points. Each angle is made in three lengths with the ends carefully fitted to bearing on the horizontal legs of the flange angle.

At the tower or double bent 13, the 125-ft. 4-in. and the 120-ft. 8-in. girders of span No. 7 are seated on one of the twin transverse girders and project beyond it to the second twin transverse girder on which they take bearing with narrow sole plates. The end of the longitudinal girder is 4 in. clear of the first half of the transverse girder on center lines, thus leaving abundant clearance for the support of the longitudinal girder of the adjacent span. The girders of span 7 have their webs reinforced by double cover plates and two pairs of 6x6-in. vertical stiffener angles 31 in. apart over the bearings of the transverse girders. At all of the other bearings of the longitudinal girders the webs are similarly reinforced, but the cover plates are only 18 in. wide. The web plates are cut to make a cambre of 1¼ in.

The girders are X-braced in vertical transverse planes at alternate panel points with single 5x3½x⅜-in. diagonal angles and double 4x3x⅜-in. horizontal angles riveted together back to back on opposite sides of the vertical connection plates field riveted to the web stiffener angles and slotted near their center point to clear the horizontal leg of the inner flange angle. At intermediate panel points the horizontal transverse angles are flush with the horizontal legs of the inner flange angles, at the ends of the girders they are separated farther and are made flush with the horizontal legs of the outside flange angles. The girders are X-braced in the planes of the horizontal legs of the inside top flange angles, each diagonal member is made with a pair of 4x3x½-in. angles riveted together back to back. One member is continuous in each angle and the other is cut to clear it and splices with a horizontal flange plate shop riveted to the flange of the long angles.

The transverse girders in the top of the tower are conected together by full-depth solid web vertical diaphragms perpendicular to the transverse girder webs and the center lines of the columns and of the longitudinal girders. The diaphragms are made with 96x⅜-in. web plates and pairs of top and bottom 6x4x⅜-in. flange angles. The diaphragms are connected to the webs of the tranverse girders with field riveted bent plates about 14 in. wide.

The Erie Railroad construction department is in charge of Mr. J. M. Graham, vice-president, and Mr. Francis Lee Stuart, chief engineer, under whose approval the viaduct, including the foundations, was designed by Mr. Mason R. Strong, engineer of bridges and buildings, with the assistance of Mr. F. A. Howard, assistant engineer of bridges and buildings. The inspection is in charge of Mr. W. H. Wilkinson, inspector of bridges of the Erie R. R. The metal work was furnished by the McClintic-Marshall Construction Co. and will also be erected by them.

A Burr Truss Bridge consisting of five spans, each about 225 ft. long, was taken down recently at Pittsburg. It spanned the Allegheny River at its confluence with the Monongahela River, and was built in 1874 for the Union Bridge Co. and maintained as a toll bridge. The entire structure, including trusses, footwalks and roadway, was enclosed by a wooden covering, roofed with sheet iron. The removal of the bridge disclosed the fact that, though it had deteriorated in parts, it could have been made serviceable for many years with easy repairs. The principal reason for its removal was the fact that it was too low and hindered river traffic. The timbers and the iron tension rods were, on the whole, in excellent condition. The removal of the bridge was accomplished by placing ten timber bents under each span, five to each truss, and then dismantling the arch, allowing the weight of the trusses to come on the stringers on top of the bents. Each bent rested on five piles driven for that purpose in the river bed. The bridge was taken down by the Dravo Contracting Co.

Speed Regulation of High-Head Water-Wheels.

There are few features of hydraulic power plants operating under high heads that are more puzzling than the speed regulation of the wheels. It is not many years since serious troubles were experienced in starting up some plants in the West which had been provided with sensitive governors that had given entire satisfaction in plants operating under low or medium heads. This trouble took the form of great speed fluctuations, which the governor seemed to increase rather than diminish, and it is understood that occasionally the long steel penstocks leading to the wheels were injured by violent pulsations of the water. An interesting discussion of this problem has recently been contributed by Mr. H. E. Warren to the "Technology Quarterly," from which the following notes have been taken.

In the case of an impulse wheel, the great waste of energy which occurs when speed regulation is attained by deflecting a part of the water from the vanes, has brought about the design of such wheels where the jet of water is not deflected at all, but instead the cross-section of the stream is altered by means of a needle valve in the nozzle. The construction is such that the stream flows through the annular space between the inner surface of the nozzle tip and a peculiar valve spindle, the two parts being held concentric by force of the flowing water. When these parts are properly designed the stream does not remain hollow, as might be expected, but converges to a solid cylinder of water a short distance from the nozzle. By moving the valve spindle back and forth axially, the width of the annular space through which the water flows may be changed at will, and thus the efficiency of the wheel may be kept high throughout the entire range of output. the only important objection to this type of wheel, according to Mr. Warren, is that an element of great danger is introduced by such sudden variations in the velocity of the water in the long pipe line which must invariably be used.

In order to get the benefit of safe and good speed regulation, impulse wheels are now furnished with combination deflecting nozzles which have needle valves, the governors being designed to control the deflection, and some other means provided to produce slow movements of the needle valves. Ordinarily with this arrangement the needle valve which regulates the cross-section of the jet is adjusted from time to time by hand as the maximum load varies, so that the governor in order to maintain constant speed is obliged most of the time to direct the stream almost, but not quite, squarely against the moving buckets. If the load increases so that the portion of the stream which is held in reserve by the governor is inadequate to maintain the speed during sudden peaks in the load curve, the cross-section of the jet is increased by an attendant.

By a device recently invented the need of an attendant to look after this detail may be eliminated. Instead, a small electric or water motor is mounted on the nozzle, so that it may move the needle valve in or out very slowly. Control contacts or valves for the motor are arranged to actuate it in a proper direction whenever the main nozzle is deflected away from a predetermined position by the governor. As a result, the cross-section of the jet will be maintained at a certain margin above that necessary to carry the average load.

The function of a governor in connection with a water-wheel is to maintain the speed nearly constant. In order to do this it must be able to control the water acting upon the wheel; generally it must be able to exert great force. Since the load is liable to change rapidly, the governor must move quickly. Since the governor cannot act at all until the speed has departed from the normal, it is important that it should be exceedingly sensitive to slight speed variations and should begin to move as soon as they occur. Because the speed cannot return to its normal value as quickly as the governor moves, the machine must act and then wait for the speed to return. The governor ought to be able to act, according to Mr. Warren, when the water-wheel is standing still, for otherwise some other means must be used in starting.

As regards force exerted in action, governors are now in constant service which develop at their normal rating 50,000 lb. push at the piston rod. For speed of action the limit at present on small governors is somewhat less than one-half of one second for a complete stroke, which means that the governor can shut off or turn on the entire supply of water to the wheel within that interval. The largest governors have a maximum speed of from one to three seconds per stroke. Regarding sensitiveness, it is possible to make adjustment while the governor is in action. Variations within one-half of 1 per cent. cause prompt movement; in fact, it is not easy to measure the smallest variations which will be felt by the machine. The feature of waiting, after it has moved the gates a proper distance, for the speed to return is called anti-racing. This may not be expressed in units, but is quite satisfactory under actual conditions.

The speed regulation of high pressure impulse wheels with deflecting nozzles is the easiest problem in governor engineering. A small regulator developing from 2,500 to 7,000 ft.-lb. is powerful enough for the largest units, and should be of the oil-pressure type, according to Mr. Warren. The degree of speed regulation which can be obtained is about the same as with a steam engine.

The problem of getting the best possible speed regulation from a high pressure turbine or an impulse wheel with needle valve control needs very careful thought if, as is nearly always the case, either of these is located at the end of a long feeder pipe. The great difficulty is that a long column of water possesses so much inertia that its velocity cannot be changed with sufficient rapidity, and moreover the changes in rate of flow which actually occur introduce a element of great danger. Imagine a turbine operating at the end of a feeder pipe 5,000 ft. long. Assume a maximum rate of flow in the pipe of 8 ft. per second, which is frequently exceeded. If the head were 400 ft. and the pipe 5 ft. in diameter this would correspond with an output of 5,600 h.p. In such a case the actual weight of water in the pipe would be slightly over 3,000 tons, which exceeds that of a loaded freight train half a mile long. Now 8 ft. per second is 5½ miles per hour, and it does not require very deep thought to see that it would be a rather difficult operation to start such a train from rest, bringing it to that speed within a second or two; it would not be much easier by the use of the engine alone without brakes to bring such a train back to rest again in the same time interval. Yet this is just what some engineers expect can be done to an equivalent water column. If the water and pipe were absolutely inelastic, it would be easy to calculate the average pressure in pounds per square inch which would be required to stop the moving water within, say, two seconds. This would be equal to about one-eighth of the weight of a column of water of 1 sq. in. section 5,000 ft. long, because 8 ft. acceleration in two seconds is approximately one-eighth as great as the acceleration due to the weight of a substance acting on its own mass. This amounts to 271 lb. per square inch, while the static head is only 171 lb. per square inch. As a matter of fact, the pressure induced in stopping the moving water column by the action of a governor upon the gate of the turbine would greatly exceed this amount, because the retarding action would not be distributed uniformly over the two-second period. An exact solution of the problem is impossible because of the irregular movement of the turbine gate in combination with the uncertain elasticity of the water and pipe. While it is impossible to determine the actual initial rise of pressure caused by a sudden closing of the turbine gates, the matter is made even more complex by pressure waves, which, originating near the gate, travel back and forth through the water with the velocity of sound, setting the whole mass into vibration like an organ pipe. Because of these waves there are formed nodes and loops of pressure at various points in the length of the pipe, so that it may happen that the stress will be greatest near the middle.

The foregoing argument shows clearly the need of a relief valve wherever a feeder pipe is so long that dangerous pressures will be generated by the necessarily quick action of a governor. However, this solution is not so easy as it seems, on account of the part played by the pressure waves which run back and forth through the elastic water column. Any ordinary valve, such as is used for steam, would open and close so rapidly as to act like a reed upon an organ pipe, and thus maintain and increase the vibration of the mass. In order to be at all effective, a relief valve must be deadbeat; but it must also open quickly. Its time of closing must be long compared with the vibration pitch of the water column. This latter requirement is rather difficult with the exceedingly long pipe lines. which sometimes bring water several miles. Special valves are now built which will open instantly and consume several minutes in closing, the speed of action being, of course, adjustable.

Although it is possible to prevent excessive rise of pressure due to reduction in velocity of long water columns, no means have been devised to produce quick acceleration of the water when, because of a sudden increase in load, the speed of the turbine begins to fall. The governor will open the gates promptly, with the immediate result that the water pressure will drop, and also the already inadequate power of the water-wheel; therefore the speed will fall still farther and the governor continue opening the gates until they are wide open. The reason why the pressure falls when the gates open is simply on account of the inertia of the mass, which cannot keep pace with the demand for water. After a certain time interval, which may be several seconds, the water column will have accelerated sufficiently to supply what is needed by the turbine. By this time, however, the speed may be far below normal. There will be a rapid acceleration of the water-wheel, which will pass normal speed because of the excessive gate opening, and as a result the governor will close the gates quickly, causing the relief valves to operate. If the governor is not made very deadbeat and rather sluggish, this cycle of events will be repeated to the great detriment of the speed regulation. When the governor is made sufficiently deadbeat so as not to encourage pressure oscillation of the water column, it will be found that the speed regulation is poor if the load changes are large and sudden; it is impossible for this to be otherwise, because the water column cannot possibly alter the energy given to the wheel fast enough, whether the gates be in one position or another.

The only complete remedy for the troubles in speed regulation caused by excessive inertia of a water column is some form of by-pass valve directly connected with the water-wheel gates, arranged to open as they close, and thus keep the velocity of the column nearly constant. An arrangement of this kind is substantially equivalent, as regards water efficiency, to an impulse wheel with deflecting nozzle. This involves a frequent waste of water equal to that required for the largest load variations, and cannot well be permitted in many installations. Therefore in such power plants as have been described some compromise is usually reached. Speed regulation is partly sacrificed for the sake of water economy. Frequently such stations are connected electrically with others where the hydraulic conditions are favorable to good speed regulation. This arrangement ensures the even speed of the whole system with good efficiency.

The predetermination of speed regulation obtainable under given conditions is of great importance, and has been left too much to governor manufacturers, in Mr. Warren's opinion. As a result their salesmen have sometimes made guarantees that were impossible of fulfillment without changing the laws of physics. He submits an analysis of the problem which leads to the following equation of the relation between the percentage temporary change in speed, d, the time required for the governor to make a stroke, T, the moment of inertia or flywheel effect of the revolving parts, I, the normal revolutions per minute, S, and the horsepower output from the wheel before and after a change, p and p_1 respectively:

$$d = 81{,}000{,}000\ T\ (p - p_1) \div I\ S^2$$

From the form of the equation it is apparent that the percentage speed variation is directly proportional to the slowness of the governor. Under certain conditions the effect of the governor in promptly adjusting the output of the water-wheel after a load change is interfered with by the inertia of the water column in the penstock, and in such cases the predetermination of speed variation is sometimes very difficult. For simple deflecting nozzles with tangential wheels and with most turbine installations the formula is of great service.

Of the quantities in the equation there is one, T, which cannot be exactly determined. Any governor manufacturer will state the time required for a complete stroke of one of his governors, but it should not be assumed that fractions of the stroke will be covered in correspondingly lesser intervals. Experience shows that short governor movements take place at a much slower rate of travel than long ones. It is necessary that this should be so in order to prevent overtravel in adjusting the output of the water-wheel. As a matter of fact, one may assume, without introducing a serious error into the calculations, that the time T required for any governor to alter the power of a water-wheel after a great or small sudden load change will be approximately constant and equal to the time required for a full stroke.

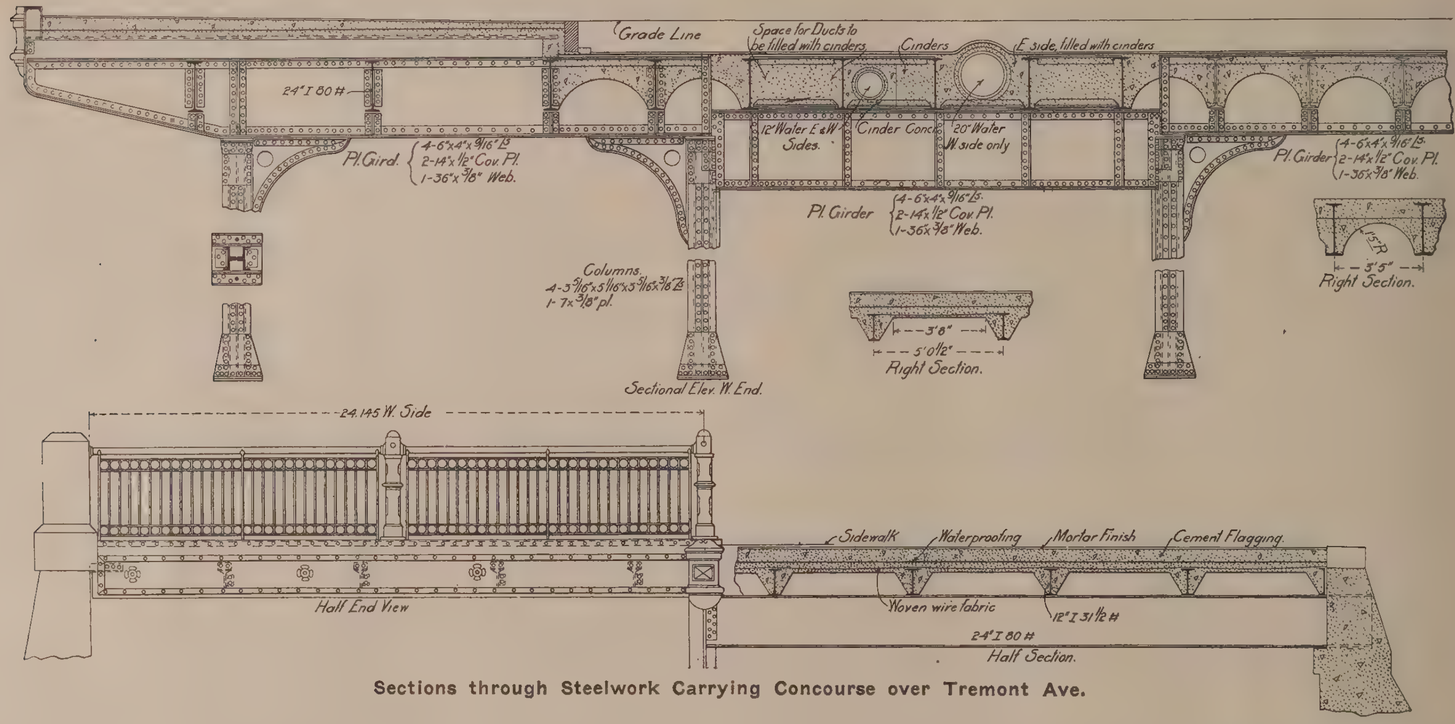
After a power plant is in operation, it is often necessary to determine, among other facts, whether the speed regulation is as good as was guaranteed by the governor manufacturer, or at any rate as good as it should be. A method of obtaining simultaneous measurements of load, voltage, and speed has been devised by Mr. Warren which is free from instrumental defects, and which, while requiring only one or two skilled men for its use, will give results of great value in any power plant where there are two or more independent alternating current units.

It is evident that the number of cycles per second of current generated by any alternator could be used to measure the speed if these cycles could be accurately counted. The oscillograph provides means for doing this in a very interesting way. This instrument is a sensitive reflecting galvanometer, which has such an exceedingly short period of vibration and is so deadbeat in action that the actual current wave, varying, even though it may, as rapidly as several hundred times a second from a positive to a negative value, can be accurately followed and recorded on a sensitive photographic film. If the film could be moved at an absolutely uniform rate, so that the trace of the current value would be drawn as an approximate sine curve, it would be necessary merely to measure the spacing of this curve in order to determine the frequency of the generator and, consequently, its speed. It is not easy, however, to provide absolutely uniform motion for the film, and there are some other difficulties in the way. Since, however, several oscillograph curves may be superimposed on the same film, it is not necessary that the sensitive photographic surface should move at a uniform rate, because one sine curve may be measured in the terms of another sine curve. If one of these is known to pass through a constant number of cycles per second, it may be adopted as the standard unit of time, and its waves, as shown on the film, be used to measure the number of cycles per second of the other curve and, consequently, the speed variations of the machine under test.

The measurement of the comparative frequency of the two curves becomes a very simple matter if they are allowed to overlap on the film, because in such a case interference effects are produced in a very beautiful manner. These interferences are due to the fact that at times the traces of both curves overlap on the film so as to produce a single line; while at other times, one curve having gained part of a cycle over the other, the two lines will be side by side and more or less confused. When the speed of motion of the film is right, the negative shows alternate shaded bands, the distance apart of which, when counted in cycles, is an accurate measure of the relative speeds of two generators being compared. Everything depends upon one generator running at constant speed. In practice it is not difficult to fulfill this condition with ample precision. To do so the generator, which is to serve as a standard measure of time, must be given a perfectly steady load, or, better still, no load at all, excepting the trivial current required by the oscillograph. The gate of the water-wheel which drives it should be disconnected from its governor and fixed in position. The water pressure upon the wheel should be maintained very nearly constant. The generator should be allowed to run fifteen or twenty minutes before measurements are made. Its speed should be observed very carefully by a sensitive recorder of some kind in order to be sure that it is steady. A frequency indicator will answer very well for the purpose, even though its graduations may be far from correct, because it is to be borne in mind that steady speed is the only desideratum. The great inertia of the revolving parts of the water-wheel and generator in the absence of any external load will be found to maintain the speed with remarkable uniformity. There should be no trouble at all in keeping this standard machine steady within 0.1 per cent. without any difficult manipulation of the water-wheel gate. The frequency of this standard machine should be adjusted 5 or 6 per cent. below or above that of the normal frequency of the machine of which the speed is to be measured.

Assuming that the standard generator is running 5 per cent. in speed below the normal frequency of the machine under test, it is clear that the fast machine should gain five cycles over the standard in 100 cycles; or, in other words, the interference points should be twenty cycles apart. If, however, the machine under test should drop in speed 5 per cent., it would then have the same frequency as the standard machine, and the interference points would be an infinite distance apart. If the loaded machine should gain 5 per cent. above its normal speed, it would then be 10 per cent. faster than the standard one, thus gaining ten cycles in each 100, so that the interference bands would be spaced at ten cycle intervals. The extreme precision of the method is shown in the large variation in the spacing of these interference bands, corresponding to comparatively small variations in relative speed. Another great advantage of the method over any other, however, lies in the fact that not only is the speed of a machine under operating conditions determined with extreme precision, but also that the voltage of such a machine is recorded simultaneously, for the amplitude of the oscillograph curve depends precisely upon the voltage of the machine being tested. By measuring the width of the curve, the voltage value corresponding to each speed value is obtained.

Furthermore it is possible to obtain simultaneous measurements of the current output from the loaded machine, which means practically the variations in load, and this is the most important feature of all. To do this a third oscillograph mirror is impressed into service, being connected with a current transformer in circuit with the generator under test, so that the amplitude of the curve traced by the light reflected from this mirror shall indicate at every point on the sensitive film what the actual output of the generator was, corresponding to the speed and voltage shown by the other two curves. This method makes it possible to conduct a speed test of any alternating current unit, either steam or water driven, under actual load conditions, and is therefore of much greater value than any test, however accurate, under special conditions, which are never exactly the same as when in service.


Grade Line
Space for Ducts to be filled with cinders
Cinders
E side, filled with cinders
24"I 80#
Pl. Gird. {4-6"x4"x9/16" Ls 2-14"x½" Cov. Pl. 1-36"x⅜" Web.
12" Water E & W Sides.
Cinder Conc.
20" Water W. side only
Pl. Girder {4-6"x4"x9/16" Ls. 2-14"x½" Cov. Pl. 1-36"x⅜" Web.
Pl. Girder {4-6"x4"x9/16" Ls. 2-14"x½" Cov. Pl. 1-36"x⅜" Web.
Columns. 4-3 5/16"x5 1/16"x5 5/16"x⅜" Ls 1-7x⅜" pl.
Sectional Elev. W. End.
3'8"
5'0½"
Right Section.
1'5"R
3'5"
Right Section.
24.145 W. Side
Half End View
Sidewalk
Waterproofing
Mortar Finish
Cement Flagging.
Woven wire fabric
12"I 31½#
24"I 80#
Half Section.

Sections through Steelwork Carrying Concourse over Tremont Ave.

Forestry Work has been started by the Atchison, Topeka & Santa Fe R. R. in order to provide ties and other timber. It is now planting 700 acres in a ranch of 9,000 acres in Southern California with eucalyptus seedlings, and this planting is to be repeated annually, it is understood. Each tree is expected to yield six ties at the end of 15 years or about 3,300 ties to the acre. These ties will be cut from 700 acres of the orchard annually, after 15 years from the first planting, about 2,250,000 being obtained each year. As the rate of removal will be equal to the rate of planting, the same total acreage will, theoretically at least, maintain the same annual supply of ties. The cost for each cultivated tie is below that of ties of white oak now bought.

Road Intersections along the Grand Boulevard and Concourse, New York City.

The Grand Boulevard and Concourse in the Borough of the Bronx, New York City, the general features of which were described in The Engineering Record of Aug. 8, 1903, will, when completed, connect Central Park with the parks north of the Harlem River and form an important part of the city's great park system. The concourse is over 4 miles long and has a total width of 182 ft., made up of a 58-ft. central roadway for speeding, two 9-ft. cycle paths with strips of turf along each side, two 24-ft. macadam roadways for pleasure vehicles and two 20-ft. sidewalks, each flagged for a width of 8 ft. in its center, leaving 6-ft. strips of turf along each side. No heavy traffic will be permitted on the boulevard and to provide means for such traffic and for street cars to cross the line of the pleasure drive nine of the principal cross streets are to be depressed and the Concourse carried over them on a steel structure extending the full width of the new street. At the same time light traffic approaching the drive on any of these intersecting streets from either direction can reach it over ramps which lead up on both sides of the depressed roadway. These crossings are known as transverse roads. The less important cross streets will be carried over the Concourse at grade or shut off entirely. The transverse roads under construction at Tremont Ave. and Kingsbridge Road are typical of all that are to be built.

Tremont Ave. crosses the Concourse at an angle of about 70 deg. necessitating a skewed arrangement of the steel structure as shown on an accompanying plan. The depressed central roadway is 45 ft. wide between the faces of the retaining walls. The asphalt block pavement is 36 ft. wide between curbs and has a 4½-ft. cement sidewalk on each side. A line of steel columns, 18.175 ft. on centers, placed on the center line of the roadway, carries part of the weight of the steel work which will be referred to later. The concrete retaining walls in general have the sections shown in the accompanying illustrations, the section in rock where the concrete forms a face wall rather than a support being materially lighter than where the backing is earth or loose fill of any sort. At Tremont Ave. and Kingsbridge Road about 60 per cent. of the cutting was in rock.

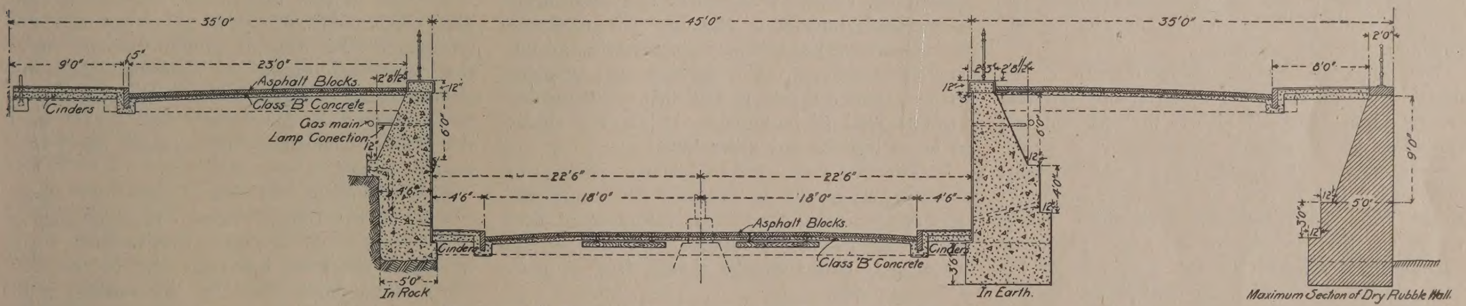
Each of the ramps carries an asphalt block roadway 23 ft. wide with a cement sidewalk on the outside. The walk is 10 ft. wide where no outside supporting wall is required an 8 ft. wide where such a wall is necessary. Outside walls are not required at the two crossings mentioned but the maximum section prescribed for such walls, which will be dry rubble, is shown in an illustration. At Tremont Ave. the depressed roadway has a maximum grade of about 3⅓ per cent., 466 ft. long. The west ramps have a length of about 325 ft. in which there is a rise of about 20 ft. The corresponding figures for the east ramps are 466 ft. and 3.4 ft.

The steel work of the overhead crossing consists of 24-in. 80-lb. I-beams parallel to the course of the boulevard, about 3⅔ ft. on centers in general, carried on the ramp walls as abutments and on a single line of plate girders on the center line of the transverse road supported by the columns before mentioned. These girders are made up of a 36x⅜-in. web plate, four 6x6x9/16-in. angles and two 14x½-in. cover plates and have 5x3½x⅜-in. stiffener angles, arranged as shown in an accompanying illustration on which is also indicated the general form of most of the steel-work details. Between the 24-in. I-beams are concrete jack arches. Two plate girders, one on the east and the other on the west side of the concourse are depressed, as indicated in the drawings to afford room for public service pipes between the I-beams, which in these panels rest on top of the girders. In the panels reserved for pipes the jack arches are replaced by 4-in. slabs of concrete between the top flanges of the I-beams and the spaces between the bottom flanges are filled metal plates, and the entire panels filled with cinders. Cinder concrete will be packed around the pipes to hold them in place and prevent freezing. To the surface of the jack arch floor will be applied a waterproofing coat consisting of three layers of roofing felt thoroughly mopped above and below with hot pitch. This waterproofing will be protected by a 1½-in. layer of Portland cement mortar, one part cement and two parts sand. The pavement on these crossings will be macadam to correspond with the Concourse paving. The details of the sidewalks carried by the steel work are shown in the drawings. The railing has a wrought-iron filling, cast-iron posts, and a 3-in. bronze hand rail.

At each transverse road a complete drainage system will be provided to carry the surface water entering the depressed road and flowing down the ramps from the Concourse into the existing system of sewers. At Tremont Ave. there are three lines of 12-in. drains on concrete cradles with brick manholes at about 100-ft. intervals. The inlets have flat cast-iron gratings. The center drain in the depressed road is for surface water only, but the drains on the ramps are for house drainage as well as surface water.

The concrete known as Class A, used in the copings, jack arches and sidewalks, is a 1:2:4 mixture of Lehigh Portland cement, stone screenings and crushed trap rock. The concrete known as Class B, in the column footings, ramp walls and abutments, is a 1:3:6 mixture of the same materials. The broken stone used in Class A concrete passes a 1-in. and is retained on a ¼-in. mesh screen. The limits for Class B concrete stone are 1½ and ¾ in.

At Tremont Ave. most of the concrete was prepared in a Smith mixer, placed near the north edge of the cut about on the center line of the Concourse. The materials for each batch were placed in a 1-yd. bucket and delivered to the mixer by a guyed derrick, with an 80-ft. boom, placed to the eastward of the mixer and operated by a Lidgerwood double-drum hoisting engine supplied with steam by a 60-h.-p. Olney & Warren boiler which also served the steam drills used in the rock cut. The mixer delivered to 3-yd. Koppel cars which were operated by hand on track laid along the outside of both ramp walls, the track for the south wall being carried across the cut on a trestle. In order to bring the cars close to the forms, so that they could be dumped directly into the latter, the track was carried on transverse timbers attached to the form studding at one end and resting on the earth or stone bank at the other. Three cars were used at once, a switch and short stub track being provided to facilitate the passing of empty and loaded cars.

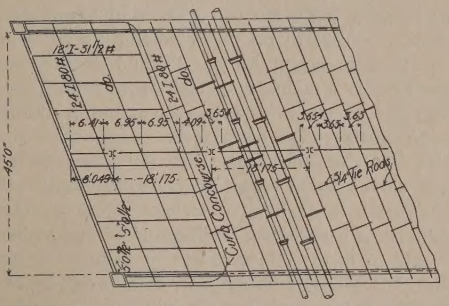


Section of Transverse Road Near Concourse Crossing.

The placing of concrete was begun at the extreme west end of the cut and the two walls were carried forward almost simultaneously. Each wall was built in 50-ft. sections and the concrete in each section was allowed to set before the next one was built, two-ply tar paper being placed in the joint to provide for expansion. A 1-in. cement finish was secured by using ⅛-in. sheet steel face plates, 6 ft. long and about 14 in. wide. The centering for the jack arches between the 24-in. I-beams was supported on cross pieces hung from the lower flanges of the I-beams with L-bolts in the usual manner.

At Kingsbridge Road the stone excavated in the cut is crushed for use in the wall concrete. An oscillating crusher with a capacity of about 60 yd. per day, made by the Farrel Foundry Machine Co., is set up on the north side of Kingsbridge Road, about on the center line of the Concourse. It is operated by a double cylinder vertical Westinghouse Machine Co. engine and produces screenings and ¾-in. to 1½-in. stone. The uncrushed stone is delivered to the platform of the crusher or to storage piles nearby by two guyed derricks on the north side of the cut located near each side of the Concourse. These derricks have 85-ft. masts and 80-ft. booms, and are operated by Lidgerwood double-drum hoists supplied with steam by a central boiler plant composed of an 80-h.-p. Olney & Warren boiler and a 40-h.-p. boiler taken from a New York elevated railway locomotive. These boilers also serve the crusher and mixer engines and the steam drills.

The crusher product is delivered to a bucket elevator which hoists it to the screen over three elevated bins holding about 9 yd. each. These are a few feet east of the crusher. About 20 ft. north of the elevated bins is a guyed derrick, with a 40-ft. boom, handling a 1-yd. bucket. The proper quantities of screenings and larger aggregate are drawn into the bucket from the bins; cement is added from the cement shed just north of the crusher; and the whole is delivered as a batch to the Smith mixer which is on an elevated platform about 30 ft. east of the derrick. The mixer delivers to Koppel cars which are handled on tracks carried just behind the wall forms as at Tremont Ave.



Part Plan of Steelwork, Tremont Ave.

General supervision of all work on the Grand Boulevard and Concourse is exercised by Mr. Josiah A. Briggs, chief engineer of the Borough of the Bronx, New York City. The work is under the immediate supervision of Mr. S. C. Thompson, principal assistant engineer of highways, under whose direction the structures described were designed. The construction work, which is now in charge of Mr. Chas. Gartensteig, assistant engineer, was begun by Mr. R. H. Gillespie, assistant engineer, who resigned last May, Mr. J. C. Rogers, Jr., is the general contractor. The steel work for both Tremont Ave. and Kingsbridge Road was fabricated by the American Bridge Co., and will be erected by the Terry & Tench Co., New York City.

The Water encountered at some places during the boring of the Simplon tunnel was remarkable for the entire absence of chlorine from it, in which respect it was new to chemists. Several geologists and analysts have reached the conclusion that the water had never been on the surface of the earth, but no very satisfactory explanation of its presence in the rock at the location of the tunnel has yet been made.

The Choice of a Bituminous Coal.

By R. H. Kuss, Secretary, Committee on Smoke Abatement of the City Club of Chicago.

An ever-recurring problem confronting the operating engineer is that of determining which coal is best suited for his purposes, everything considered, for although he may have reached a satisfactory conclusion at one time, circumstances are bound to arise subsequently which make it desirable to renew the investigation. To the careful buyer, the problem of selecting coal divides itself naturally into a consideration of the following main topics:

1. Availability, contingent upon the location of the mines, labor conditions, transportation, etc.
2. Relative costs of evaporating a certain unit quantity of water or its equivalent.
3. Flexibility and adaptability of the coal within the capabilities of the apparatus in which it is used.
4. Degree of smoke reduction attainable.
5. Quantity and quality of the resulting refuse and ease of its handling or removal.
6. Effect of treatment of the most desirable coal on all of the previous items.

The items enumerated are necessarily interdependent, and, of course, dependent also upon the apparatus in which the coal is used and upon the character of the available labor. The scope of this article will, however, be restricted to the consideration of the six divisions mentioned, with only such incidental references to the apparatus and the method of firing as may be necessary to indicate the leading factors to be treated.

Under the head of availability it is safe to assume that the ordinary plant is destined to lean toward the use of a coal of a character like that which comes from the nearest mines reached by competing coal railways. The force of this influence is particularly noticeable with mechanical stoker installations which may be built particularly for a coal of a special characteristic, such as a coking quality, which eventually gives way to a cheaper coal, however unsuited the latter may be for the apparatus on which it is burned. It is true that in small plants, where there is a likelihood of inadequate equipment and the coal bill forms a small percentage of the total plant operation cost, little attention is sometimes paid to this matter. It is no less true, however, that the good intention of an owner to buy a superior grade of coal in the beginning, so as to reduce smoke emission or the like, is likely to give way to the use of the cheapest available fuel, sometimes even at an increased cost in some other item than the bill because the auxiliary expenses of coal use are not so easily recognizable as the cost of the fuel itself. Most consulting engineers fail to appreciate and to provide for this natural tendency and consequently complain because their specifications as to operation are not fully complied with, when, as a matter of fact, their grievances are not so serious as those of the owner who pays toll every day for the shortcomings of the consulting engineer. Obviously, the conclusion should be that the furnace design should provide the best available means for the use of the coal nearest at hand, whether that requires an additional initial expenditure or not. Any other course is a makeshift and an example of poor engineering.

The cost of evaporating a unit quantity of water is contingent upon the circumstances of operation, the available equipment and similar factors. By the time the final decision as to the coal to be used is reached the equipment has already been provided and no longer is to be considered a changeable factor. In deciding which is the cheapest fuel to use, it is a mistake to assume that the matter can rest with the relative showings of the particular coals tested, though it would appear at first sight that everything has been taken into account by such a course, the apparatus, as said before, not being considered capable of change to meet the requirements of the different grades. The force of the foregoing statement is apparent from a consideration of the relative costs of handling the refuse, the wear and tear of equipment, the care required for firing to obtain results comparable with those of the tests, and the effect of dust of the fuel on the surrounding firing room and contiguous properties. Of these items the cost of refuse removal overlaps the wear and tear item more or less, depending upon the quality of the refuse, some of which will put an ordinary conveyor system out of commission much sooner than the refuse of other coals or that of the same basic coal treated by washing, sizing or otherwise. Of course, the quantity of refuse to be removed is indicated by the amount found on analysis, though the relative performances of two coals different in uninflammable content do not bear a like relation in actual performance, because one coal may cause a greater percentage of combustible to appear in the refuse than a comparison of the analyses would indicate, even to one who is competent to interpret analyses.

That there are serious disappointments in the use of a certain coal after an apparently fair and careful series of tests is due to the fact that test conditions are not strictly representative of working conditions. The preparation for and performance of all of the tests of a series operates to throw two wholly different coals more nearly on an equality, the coal of the lower grade receiving greater benefit by the same care in firing, whether by hand or by mechanical stoker, than the better grade. To explain by example, a good grade of coal may admit of a range of efficiency of eight per cent. between careful manipulation and ordinary firing, while the poorer grade admits of a range of fifteen per cent. The test series tends to compare only the high performance marks of the several coals while the fuel selected is used according to ordinary treatment.

Another point to be considered is that the test conditions of the apparatus, if brought back for each fuel to equal cleanliness of furnace and heat-absorbing regions at the start of each test run, are in ordinary operation put out of all comparison with the test conditions more quickly with some coals than with others. In spite of the best that can be done, the apparatus as a unit deteriorates rapidly between periods of complete cleanings for some fuels, owing to soot deposits in combustion chambers and tube chambers, while with other coals the trouble is less marked. The test series cannot serve to indicate this difference to the degree desired, although a study of minor happenings in all of the tests is of service to indicate a difference in coal behavior even in this regard. Smoke observations and chamber examinations, the latter both before and after test runs, serve to throw light on this matter. Of course, the degree of ease in removing soot and finely divided refuse from the affected regions is a salient factor in this branch of the subject.

Under the third item, adaptability of coal to the apparatus, there is one of the most difficult features attending the selection of a coal for a particular duty. Here, again, the test series is likely to fail, especially if a whole battery of boilers is available to take care of the variations of duty while the steam delivery from the apparatus employed in the test is maintained without material fluctuations. Nor will a series of tests conducted on the basis of under, even and over-capacity give the information desired. This portion of the subject can be handled to some degree by a study of the quantity and quality of the refuse, and the ease with which it may be removed if the contingency arises. For example, two grades of coal may be compared, the first being one that gives a tenacious, gummy, compact clinker and the other a clinker that is very fragile and easily broken up under the action of an ordinary rocking grate. In the first case we are restricted because the best available means of adjustment, damper regulation, is ineffective, since the resistance of the fuel bed is not capable of easy change, while in the second case we can materially affect the rate of furnace performance. It is not sufficient to dismiss this important subject by declaring that when a fire is in a condition where it refuses to respond to damper regulation it is time to clean, for that would impose the necessity for cleaning very often with some fuels, a service which, in ordinary running operation, is not likely to be performed.

In some localities it is very important to reduce smoke to a degree where it no longer is a menace. In such plants where recourse must be taken to a particular high grade of fuel either because of inadequate furnaces or because of the nature of the service demanded in order to reduce the smoke emission, the situation is indeed unfortunate and the real remedy is a substitution of furnace or method of coal use. An inadequate furnace arrangement imposes, necessarily, an undesirable restriction as to kinds of coal available for use, though it may be said that a bad furnace for one kind of bituminous coal is very likely to be as bad for any other kiud.

In selecting a coal for the primary purpose of avoiding smoke, more progress can sometimes be made by trying the several variations of sizes of a promising coal from one field than by experimenting with a number of coals from as many different fields.

The quantity and quality of the refuse have been previously considered as an important factor under several heads. The quality of the refuse is the more important, since it bears upon the proposition of resistance to air passage to a larger degree than the quantity itself, and besides is the leading factor in determining the ease with which it can be removed. In certain mechanical stokers this matter becomes less important than for hand-firing, though in others it is more important.

The treatment of which a coal is capable presents to the user a field of speculation that seems to offer promising results. First to be thought of in this connection is sizing, the separation of the coal into several groups of which the pieces are of approximately the same weight. The advantage of this treatment is that the percentage of voids in a given thickness of fuel, the pieces being of irregular shape and not fitting into each other, approaches a maximum the more nearly uniform they are in size. Spheres of the same diameter present when piled into heaps a fixed percentage of unfilled space or voids irrespective of what the diameter may be. Now, the same holds true, but to a less extent, with uniformly sized coal. Hence, in the case of a bed of sized coal we may expect to use a thicker layer than with mixed coal. This means that it is possible to have a thicker bed of incandescent fuel on the grate, thereby causing a smaller variation of furnace temperatures to come about when green fuel is fired. Again, it is possible with a thicker fuel layer to have a greater variation in fuel bed thickness with less deleterious results than with a thin layer. It is not difficult to see that the thicker layer can be put on just as evenly as a thin layer, and the same degree of unevenness will not be relatively so important in the case of the thick layer as in the thin fuel bed. Again, the thicker layer of fuel presents an opportunity of taking care of an increase in the demands on the furnace without the same increase of quantity of coal fired that obtains where the fires must be kept thin.

Still another factor must be mentioned before dismissing the subject of sizing, the amount of surface presented to the gases passing through the fuel bed. While the percentage of voids is independent of the sizes themselves, the total surface for a given mass of fuel is a function of the size, becoming rapidly greater as the pieces become smaller. One would naturally expect the greatest surface to be the most effective, which would hold true were it not for the fact that the rate of volatile distillation might become too high for the capacity of the furnace, or if smaller coal did not result in a more compact layer of refuse than larger coal. The tendency surely would be to reduce the size of the coal the better the furnace facilities, other features of the coal being the same, if they can be.

An entirely different aspect of the case comes about in a forced draft installation, for to gain the best results it may not be desirable to impose as little resistance to air passage through the incandescent fuel bed as possible. It is probable that the sizes may well be mixed in such a case, rejecting the smallest as well as the biggest and retaining everything between them.

The use of coal dust under ordinary natural draft conditions is, of course, not a reasonable application of the principle of uniform size selection, since this imposes an abnormally high resistance to air and gas passage. The small interstices demand an exceedingly thin fire to gain the proper combustion rate, a matter nearly impossible in coal of very small size.

The washing of coal is a comparatively recent venture in the Illinois region and unfortunately is not always well done nor effective when every intelligent effort has been expended on the coal. The common impression exists that washing is always beneficial whereas it is sometimes decidedly the reverse. Even in those cases where an apparent gain is made, the good results very often come from the sizing rather than the washing. Comparatively few coals exhibit any noticeable degree of betterment after washing, and in many cases the latter imposes a decidedly unnecessary hardship. A guide to whether a betterment comes about is to compare the analyses of the coal before and after washing. If the ratio of amount of sulphur to the total refuse after washing is greater than before or even equal to it the fuel has not been improved sufficiently to warrant the expense, if a use of the unwashed fuel shows it to be a serious one to handle because of the nature of the clinker. The foregoing test does not follow absolutely, since the washing process may remove the most objectionable sulphur portion allowing the unobjectionable portion to remain. This belief is not commonly entertained, because those who have to do with the use of coal by a study of the analyses are over-impressed with the greater percentage of pure coal remaining after washing. The experiences of the operative are more to the point, however, since he deals with the difficulties of the resulting refuse, not so much because of its quantity but because of its character.

The use of a mixture of small size anthracite and bituminous is one of the best fields of investigation to be considered in this connection. This course is very effective where the bituminous coal results in a particularly stubborn clinker. The presence of the anthracite refuse in such a case serves to offer innumerable places for clinker fracture when the coals are combined and thereby makes the refuse bed easily tractable. On shaking or rocking grates the advantages of this method are strikingly evident. The combination need not be made with equal parts of the two coals, but different proportions may be tried until a workable combination is arrived at. Necessarily, the effect of combining a high fixed carbon coal with a high volatile one is to create a fuel which is more easily made to conform to an inadequate furnace than a bituminous coal alone.

Ore Handling in the Marquette Iron District.

The mines in the Marquette, Mich., iron-ore district have been worked for over fifty years, but the output from this district has been greatly increased only in the past eight or ten years. The principal mining centers in the district are at Ishpeming and Negaunee, which are about 15 miles from Lake Superior in a direct line, although many other important mines have been developed at various points throughout the district. Two classes of iron-ore are mined in the district, one in the form of very hard rock and the other more like dense clay, or heavy soil. The mines are all worked from shafts, which vary from 100 to 1,000 ft. in depth. The ore is taken out at several levels in each shaft, the spacing of the levels depending largely on the manner in which the ore occurs. Most of the hard-ore mines can be worked without timbering, so the ore is generally removed from the deposits as the headings advance from the shaft. In the soft-ore mines, on the other hand, the general practice is to drive a heading from the shaft to the limits of the deposit to be tapped, and then work back toward the shaft in mining. In this method, only enough timbering is used to hold the roof temporarily, the ground being permitted to cave after mining operations have ceased.

The ore is hoisted from the shafts in the cars in which it is loaded at the working face. When ore is being shipped immediately, it is dumped from the mine cars through a tipple into standard-gauge cars. The remainder of the time it is dumped into stock piles, from which it is loaded into the standard-gauge dump cars by means of steam shovels.

The natural outlet for the district is Lake Superior, which is reached most practically at Marquette, 16 miles from Negaunee, and 19 miles from Ishpeming. A large tonnage of ore, nevertheless, is carried by rail to Escanaba, on the west shore of Lake Michigan, for transportation by water to the steel mills at the lower end of that lake, and also to the lower lake ports. At Marquette the ore is delivered to vessels which carry it to various distributing and industrial ports on the Great Lakes.

The Lake Superior & Ishpeming Ry. was built from Ishpeming to Marquette by the Cleveland-Cliffs Iron Co. and allied interests to handle the output of the mines controlled by that company and those interests. Something less than half of the output of the mines in the neighborhood of Negaunee and Superior is carried by this railroad. The latter is built with 80-lb. rails and has thoroughly modern equipment adapted to the traffic tributary to it. The standard ore cars of the road are of steel and have a capacity of 50,000 lb. They have two four-wheel trucks, and as they are only 24 ft. long, over all, a very concentrated load is brought on the track and structures by them. Ishpeming is 850 ft. above Marquette, so the line is practically down grade all the way, although the maximum gradient is about 1.63 per cent. Consolidation type engines having 22x30-in. cylinders, 80-in. boilers and a combined weight of engine and tender of 173 tons are used in the ore traffic. These engines haul forty-five loaded 50,000-lb. cars to Marquette and return with 45 empties, without a helper at any point, notwithstanding the fact that there is a continuous climb of about nine miles, in which the maximum grade occurs several times. These engines are each equipped with two air pumps for the air-brakes, either pump having sufficient capacity to furnish enough air to operate the brakes of a full train. Since the brakes are applied a considerable portion of the time on the downward trip, the wear on the wheels is heavy, but it has been found that the wear on the tires of the locomotive wheels can be greatly reduced by applying a fine stream of water to them while the brakes are set.

The ore is unloaded from the trains into the vessels through a long, high dock at Marquette. This dock and most of the approach to it are a continuous timber trestle, the dock proper being on piles cut off at the water level. The approach rises on a 2 per cent. grade for about 2,300 ft. The dock is 54 ft. high above the water, 1,200 ft. long and 52 ft. wide. It has two longitudinal rows of ore pockets, one on each side of the center line, and will hold approximately 30,000 tons of ore. Four tracks are extended the length of the dock over the pockets, the latter being spaced so the center dump hopper-bottom cars which are used can be placed one at each pocket. The cars are handled up the approach 15 to 18 at a time by a 130-ton geared Lima locomotive; the switching on the dock is done by an ordinary locomotive.

The ore is fed by gravity from the storage pockets into the holds of the vessels through hinged chutes, which can be raised to permit vessels to pass. In addition to the trainmen and switchmen on the dock, a force of laborers is required to raise and lower the loading chutes and to loosen the ore as it becomes jammed in the pockets. The soft ore, in particular, causes considerable trouble from this source, but the hard ore generally flows readily.

The number of ore trains operated over one of the ore roads each day and the total tonnage for the season of open navigation on the lakes, which averages about seven months, naturally depends chiefly on the output of the mines tributary to it. During the season of 1906 in the neighborhood of 1,800,000 tons of ore were handled through the dock of the Lake Superior & Ishpeming Ry., practically all of which came from mines in the vicinity of Negaunee and Ishpeming.

The Duluth, South Shore & Atlantic Ry., which carries the remainder of the ore traffic passing through Marquette, handled about 1,700,000 tons in 1906 over the three docks which it operates there. Two of these docks are older structures, but the third was completed during 1906, and is now used chiefly for the ore traffic of this road. It is similar in arrangement and construction to the dock of the Lake Superior & Ishpeming Ry., except that the tracks on it are 74 ft. above the water, in order to facilitate the loading of the very large ore-carrying vessels which have been placed in service during the past few years.

The total quantity of iron-ore which passes through Marquette, 3,500,000 tons in 1906, is only a little more than one-tenth of the total tonnage of iron-ore that passed through the locks at Sault Ste. Marie last year. A large percentage of the remainder came from the Mesabe and Vermillion districts, to be northeast of Duluth. The construction, equipment and operation of the roads which deliver ore from those districts to the docks along Lake Superior are much the same, however, as those of the Lake Superior & Ishpeming Ry.

Book Notes.

A little more than a year ago attention was drawn in this journal to the special structural shapes which the Bethlehem Steel Co., South Bethlehem, Pa., will roll on its new universal mills and some of the properties of these shapes fitting them particularly for bridge and building work were pointed out. The company has now issued a handbook prepared by Mr. George H. Blakeley in which complete tables of these properties are given and standard details for connections are illustrated. This pamphlet, entitled "Bethlehem Special Structural Shapes," contains information that every designer of steel work will find it desirable to have at hand, for the company will shortly be ready to begin shipping these shapes.

The Office of Public Roads has recently issued a pamphlet on "Rocks for Road Building," written by Mr. E. C. E. Lord, petrographer of the Office, which describes in some detail with the aid of excellent engravings the most important quantitative methods of rock analysis by means of the microspoe and proposes a classification of material suited for highway construction. Since the establishment of the laboratory of the Office in 1900, over 1,500 samples of rock from nearly every State, as well as Cuba, Porto Rico and Hawaii, have been examined miscrosopically and physically tested. The average mineral composition and physical properties of these samples are given in tabular form, and the various road-making rocks are arranged so far as posible according to their genetic relations, as shown by the tests and examinations. The general conclusions regarding these materials are stated as follows: (1) Igneous and metamorphic rocks, owing to a higher degree of crystallization and a preponderence of silicate minerals, offer a greater resistance to abrasion than nearly all varieties of sedimentary rocks. (2) The coarse-grained intrusive rocks of the igneous class are harder, but break more readily under impact, than the finer-grained volcanic varieties of like mineral composition. (3) The deleterious effect of atmospheric weathering on the wearing qualities of rocks is evident. (4) The cementing value of rocks is, to a certain degree, measured by the abundance of secondary minerals resulting from rock decay. (5) Metamorphic rocks have, as a rule, a low binding power owing to a regeneration of secondary minerals and to the effect of heat and pressure. The foliated types readily part along planes of schistosity and are therefore not well adapted to road construction. (6) The quantitative mineral analysis of rocks serves to a certain extent as a measure of their useful properties for road construction. The pamphlet may be obtained by applying to the Office of Public Roads at Washington.

With the widespread interest in the development of water powers there has arisen a demand for a thorough treatise on turbines, and engineers who are familiar with the German language will doubtless find this need well satisfied by "Die Turbinen fuer Wasserkraft-betrieb," by Prof. A. Pfarr, of the Darmstadt Polytechnic Institute, who was associated for twenty years with Dr. J. M. Voith, the well-known turbine builder, who has done much to raise the standard of such machinery. The book is voluminous and goes into great detail in places, and suffers somewhat from the absence of a good index. On the other hand, it is written from a viewpoint with which The Engineering Record is in complete sympathy and is marked by an absence of obsolete and useless illustrations that is almost as gratifying as the excellent drawings and diagrams that are provided. The author points out that the theory of what water actually does in turbines is based on a great many assumptions, and the best that can be done is to use extreme care in selecting those assumptions which are most likely to be correct, and then to test the theories by careful experiment. The formulas deduced by theory and fitted with working constants derived by experiment have limitations due to both the range of experiment and the liability of error in the assumptions of the theory. Consequently only those who know the steps by which the theory was deduced and the extent and reliability of the experiments are able to use the resulting formulas with the full knowledge an engineer should possess. It is for this reason, also, that the author has not cared to provide a compendium of formulas for "ready reference," but has illustrated his methods by carrying through complete detailed designs with a thoroughness that is likely to be particularly useful to beginners. It is very rare indeed that the complete details of such designing work are given or drawings of actual installations are dimensioned so fully as in this book. The first three chapters discuss the power characteristics of flowing water, the different types of turbines and the work of water within a turbine. Anybody who desires to obtain a good presentation of the theory of turbine action now held among German-speaking engineers will find this portion of the volume clear and comprehensive; in fact, engineers who have already studied the subject somewhat may consider that the author gos into too much detail. Draft tubes and head are taken up in the next two chapters, the former subject being treated with particular fullness. Four chapters follow in which the design of different types of turbines is explained, both analytical and graphical methods being employed. The next section, running through several chapters, is one of the most complete discussions of gates and control that has yet appeared, and is succeeded by one on shafting, bearings, yokes and other parts. The remainder of the book relates to turbines actually built and their installation and governing. The work appears in a text volume of 821 pages of large octavo size and an atlas of 46 admirable plates. (Berlin, Julius Springer, 36 marks.)

Letters to the Editor.

STEEL FRAME FOR CONCRETE REINFORCEMENT.

Sir—I take pleasure in sending you herewith a picture of the reinforcement of the Owl Drug Co.'s building now under construction in Mission street, near Second street, in this city. The method of reinforcement marks an innovation in concrete reinforcement, in that the steelwork forms a complete unit before any concrete is put in place. This unit is so completely formed that it is quite practicable to erect all steelwork before any concrete is poured, as can be seen in the accompanying picture, which shows several stories of free steel.

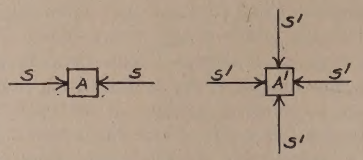
Among the advantages of this method of construction the following may be mentioned: The steel forms a complete structural unit in itself and does not cause internal stresses in the concrete, allowing the latter to perform the functions for which it was designed. Defects in the steelwork cannot escape notice, and there is little likelihood of derangement of the steel during the pouring of the concrete. The design can be computed readily and permits very quick erection.

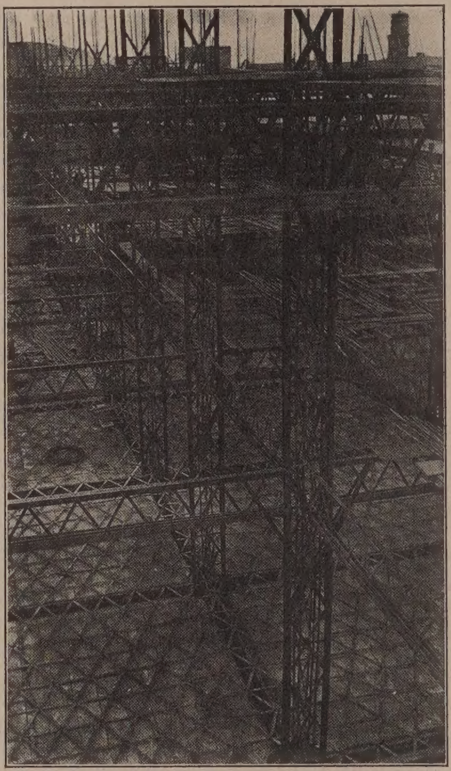
Yours respectfully,
JOHN M. ETTLER.
San Francisco, Aug. 15.

CONCRETE SLAB REINFORCEMENT.

Sir—There are two questions I would like to have answered in regard to designing concrete slabs reinforced two ways at right angles.

First, what percentage of the working stress allowed in concrete reinforced in one direction only can you allow as the working stress in each of the two directions when reinforced in two ways? For example, let A be a small portion of a slab reinforced in one direction an A^1 be a small portion of a slab reinforced in two directions at right angles. If a working stress of S=750 lb. per square inch is allowed on the extreme fiber of A, what should be allowed for the working stress S^1 on the extreme fiber of A^1?




Reinforcement in Owl Building.

Second, is the steel found by the formula $1/20\ w\ l^2$ the least amount that can be used in each direction of a slab fixed on all four sides, or is there a plate action that will permit using less steel?

Yours truly,
ROBERT G. LOSE.
Wilkinsburg, June 14.

[The answers to this inquiry cannot be made very precise, for the theory of flat plates supported on edges is in neither a very simple or satisfactory condition at the present time. It is customary to assume that the plate is supported uniformly on its edges where those edges are simply supported or held rigidly fixed. If the plate is square, it is frequently assumed that the half of the load is carried in each direction and for each direction the plate is assumed to be an ordinary beam. Just what should be taken as the working stress in the concrete for each direction is to some extent a matter of judgment. It will probably be safe to take that working stress at three-quarters of its value in an ordinary reinforced concrete beam. The resultant stress where the bending moment is greatest would then certainly be safe and reasonable. Another method justified by experiment is to take the total load as dead and as uniformly distributed around the edge of the plate and then take moments by the diagonal of the rectangular or square plate, using as the working stress that which would be permissible in an ordinary reinforced concrete beam.]

A LARGE MOVING OPERATION.

Sir—Much interest has recently been manifested in what is said to be the largest moving job of its kind ever undertaken. The new thoroughfare leading down from the heart of the business district of Brooklyn to the end of the new Manhattan Bridge, now under construction, is an extension of Flatbush avenue. It has been cut through a number of thickly built-up blocks, and one of the most prominent buildings in its path was the old Montauk Theater, later known as the Imperial Theater. This building was considered too valuable to be torn down, and efforts to save it from destruction have resulted in its being moved bodily to a new site a few feet to the eastward of its original position.

The building is of brick, with a steel skeleton, and the weight is said to be about 8,500 tons. The walls are 90 ft. high. The lobby, on Fulton street, has been torn down. The back of the old building was on DeKalb avenue, but in the new position it will be on Hudson avenue, a half block from DeKalb. The moving has consisted of three main movements; a displacement southward towards Fulton street of nearly 40 ft.; a rotation about its own center of mass (clockwise, as view from above) of about 65 deg.; and a further displacement, eastward, of more than 100 ft. to a new brick foundation, which has been already prepared for the building.

In the preparatory work, holes were knocked in the foundations, and I-beams varying from 40 to 60 ft. in length were pushed under. These were built up inside laterally and transversely at intervals of about four feet each way. Altogether, nearly 600 of these beams, representing some 1,500 tons of steel, have been used. Beneath these have been placed railroad rails on wooden ties, but the rails were not spiked down. These rails, which have the standard length of 30 feet, have been placed in groups of four to six. The steel I-beams were braced with stout timbers, and shoes some 24 in. square were built under them along the outer edge of the building, at intervals of 4 ft. Under each of these shoes, and resting upon the groups of rails, were placed in each case about a dozen steel rollers 2 in. in diameter and 24 in. long.

These preparations being made, the building was raised a fraction of an inch by means of several score of jacks, and the weight was transferred from the old foundations to the rollers on the the back of the building, on DeKalb avenue, and rails. A string of heavy timbers was run along anchored securely. Along this string were placed twenty jack screws, well oiled and working in hardwood drums. At a whistle signal, each jack was given one twist, and the building moved just the distance covered by the thread on the screws while making that portion of a revolution. In this manner the building was moved about 12 ft. in four hours.

For the twisting motion, the center of the building was indicated by a red light, and the steel rollers involved in this motion were all placed with their axes and the light in the same plane. The other translatory motion will be but a repetition of the first. The work is being done by Iverson, Gustatson & Co. A new facade facing the new Flatbush avenue will be built and then the theater will be again ready for use.

Yours truly,
Brooklyn. SIDNEY G. KOON.

BLOCK SIGNALS have been installed on 1,500 additional miles of the lines east of the Pennsylvania R. R. during the past three years, and at present the important mileage of these lines is protected, although about 500 miles of industrial and branch roads have not been equipped. The cost of the additional equipment was $856,520, and it will add $210,816 yearly to operating expenses.